Orchard Storage Company LLC

# Underground Injection Control – Class VI Permit Application for

# Orchard #2

## Gaines County, Texas

Prepared for *Orchard Storage Company LLC*
*Odessa, Texas*

By
*Lonquist Sequestration, LLC*
Austin, TX

May 2023

LONQUIST SEQUESTRATION LLC

# FOREWORD

Orchard Storage Company LLC is proposing to develop a carbon sequestration facility in Gaines County, Texas, [redacted] The Orchard Project is being designed to handle captured carbon dioxide ($CO_2$) from various emitters through multiple sequestration wells. This site is ideally suited for the sequestration of $CO_2$ with minimal existing wellbores in the area, an injection interval with requisite and appropriate reservoir properties, and substantial sealing intervals. The storage site is also relatively near existing $CO_2$ pipeline infrastructure to accommodate the economic delivery of sourced $CO_2$ volumes to the Orchard Project.

The following application will fully detail and characterize the geology of the proposed well location, evaluate the formation for properties necessary to contain the sequestered $CO_2$ permanently, and describe the engineering design and safety considerations for the well. The application will also discuss the proposed monitoring system that will be utilized to compare and contrast actual injectate plume migration to reservoir modeling and simulation of the anticipated plume.

The application has been developed to meet all of the requirements of both Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.82** through **§146.95** and the Texas Administrative Code (TAC), Part 1, Title 16, Chapter 5 (16 TAC **§5**). Both of these codes detail the regulations for Underground Injection Control Class VI wells. Once the permit has been issued, per the requirements of 40 CFR **§144.36(a)** and 16 TAC **§5.203(d)(1)(A)**, the permit will be updated every five years thereafter for the active injection life of the well.

# CERTIFICATION

CERTIFIED BY:

I, Michael Blincow, certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Michael Blincow
Sr. Vice President Subsurface Operations

# CERTIFICATION

CERTIFIED BY:

Lonquist Sequestration, LLC
Texas Registration No. F-22610

I, Ben H. Bergman P.E., certify that this application was prepared by me or under my direct supervision and that the information and analyses presented herein are true and accurate to the best of my knowledge.


Ben H. Bergman, P.E.
Senior Engineer

Ben H. Bergman P.E.

Texas License No. 95591
Date Signed: May 1st, 2023

I, Emily Olson, certify that the geologic and hydrologic evaluations in this application were prepared by me or under my direct supervision and that the information and analyses presented herein are true and accurate to the best of my knowledge.

STATE OF TEXAS
EMILY KATE OLSON
GEOLOGY
15124
LICENSED
PROFESSIONAL GEOSCIENTIST

Emily Olson, P.G.
Sr. Geologist
Texas License No. 15124
Date Signed: 4.28.2023

# ACRONYMS AND ABBREVIATIONS

Note: All terms are written as used in the text.

| | |
|---|---|
| §45Q | IRS Tax Code §45Q |
| AFI | active fracture images |
| AOR | area of review |
| API | American Petroleum Institute |
| ARM | ambient reservoir monitoring |
| ATSM | American Society for Testing and Materials |
| bbl | barrel(s) |
| bcf | billion cubic feet |
| BHIP | bottomhole injection pressure |
| BHP | bottomhole pressure |
| bpm | barrels per minute |
| CAA | Clean Air Act |
| CBL | cement bond log |
| CCL | casing collar locator |
| CCS | carbon capture and storage |
| CDP | common depth point |
| $CH_4$ | methane |
| CFR | U.S. Code of Federal Regulations |
| CMG | Computer Modelling Group |
| CMT | cement mapping tool |
| $CO_2$ | carbon dioxide (may also refer to other Carbon Oxides) |
| CRA | corrosion resistant alloy |
| CWA | Clean Water Act |
| DTS | distributed temperature sensing |
| ECP | external casing packer |
| EOR | enhanced oil recovery |
| EOS | equation of state |

| | |
|---|---|
| EPA | Environmental Protection Agency |
| ESG | environmental, safety, and governance |
| FERC | Federal Energy Regulatory Commission |
| FMI | Fullbore Formation Microimager |
| $g/cm^3$ | grams per cubic centimeter |
| GAPI | API gamma ray unit |
| GAU | Groundwater Advisory Unit |
| GR | gamma ray |
| HRVRT | high-resolution vertilog |
| Hz | hertz |
| IARF | infinite acting flow regime |
| ICS | Incident Command System |
| ID | inner diameter |
| IEA | International Energy Agency |
| $kg/m^3$ | kilograms per cubic meter |
| km | kilometer(s) |
| KM | Kinder Morgan |
| $lb/ft^3$ | pounds per cubic foot |
| Mbbls | thousand cubic feet |
| mD | Millidarcy(ies) |
| MD | measured depth |
| MDT | Modular Formation Dynamics Tester |
| MEQ | microseismic earthquakes |
| MPa | MegaPascal |
| mg/l | milligrams per liter |
| mGal | milligals |
| MIT | mechanical integrity test |
| MM | million |
| MMbbls | million barrels |

| | |
|---|---|
| MMcf | million cubic feet |
| MMscf | million standard cubic feet |
| MMscf/d | million standard cubic feet per day |
| MT | metric tons |
| MT/yr | metric tons per Year |
| MMT/yr | million metric tons per year |
| NETL | National Energy Technology Laboratory |
| OD | outer diameter |
| OIP | oil in place |
| P&A | plugging and abandonment |
| PE | photoelectric |
| PEC | Pulsed Eddy Current |
| PHIX_EFF | effective porosity |
| PISC | post-injection site care |
| ppg | pounds per gallon |
| ppm | parts per million |
| psi | pounds per square inch |
| psia | pounds per square inch absolute |
| psig | pounds per square inch gauge |
| QA/QC | quality assurance/quality control |
| QPT | Quartz Pressure Temperature |
| RCRA | Resource Conservation and Recovery Act |
| RFT | repeat formation tester |
| ROZ | Residual Oil Zone |
| rfn | rock fabric number(s) |
| SC | specific conductivity |
| SCADA | Supervisory Control and Data Acquisition |
| sDAS | seismic distributed acoustic sensing |
| SIC | Standard Industrial Classification |

| | |
|---|---|
| SOW | slip-on weld |
| SP | spontaneous potential |
| SS | subsea |
| TAC | Texas Administrative Code |
| TD | total depth |
| TDS | total dissolved solids |
| TEC | tubing encapsulated conductor |
| TRRC | Texas Railroad Commission |
| TVD | total vertical depth |
| UCL | upper confinement layer |
| UIC | Underground Injection Control |
| USDW | Underground Source of Drinking Water |
| USGS | U.S. Geological Survey |
| VSP | vertical seismic profile |
| WIRE | Well Integrity Real-time Evaluation |
| XPHI | cross-plot porosity |
| XRD | X-Ray Diffraction |

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# REQUIREMENTS MATRIX

| 40 CFR - Subpart H - Criteria and Standards Applicable to Class VI Wells | | | | | | |
|---|---|---|---|---|---|---|
| **EPA 40 CFR** | **CFR Category** | **CFR Text** | **16 TAC Chapter 5** | **TAC Category** | **Description** | **Permit Application** |
| §146.82(a)(1) | Required class VI permit Information | Information required in § 144.31(e)(1) through (6) of this chapter; | §5.203 (a)(2) | General | General information. | |
| §146.82(a)(10) | Required class VI permit Information | Proposed procedure to outline steps necessary to conduct injection operation; | §5.203 (i)(1) | Operating Information | Operating plan. The applicant must submit a plan for operating the injection wells and the geologic storage facility that complies with the criteria set forth in §5.206(d) of this title, and that outlines the steps necessary to conduct injection operation The applicant must include the following proposed operating data in the plan: | |
| §146.82(a)(11) | Required class VI permit Information | Schematics or other appropriate drawings of the surface and subsurface construction details of the well; | §5.203 (e)(2)(K) | Injection well construction | Schematic drawings of the surface and subsurface construction details. | 4.2.1 |
| §146.82(a)(12) | Required class VI permit Information | Injection well construction procedures that meet the requirements of § 146.86; | §5.203 (e)(3) | Injection well construction | Well construction plan. The applicant must submit an injection well construction plan that meets the criteria in paragraph (1) of this subsection. | 4.2.2 |
| §146.82(a)(13) | Required class VI permit Information | Proposed area of review and corrective action plan that meets the requirements under § 146.84; | §5.203 (d)(2) | AOR and corrective action | Area of review and corrective action plan. As part of an application, the applicant must submit an AOR and corrective action plan that includes the following information: | 3.8, 3.10 |
| §146.82(a)(14) | Required class VI permit Information | A demonstration, satisfactory to the Director, that the applicant has met the financial responsibility requirements under § 146.85; | §5.202 (c)(2) | Applicability and compliance | Evidence of financial responsibility. The operator acquiring the permit must provide the director with evidence of financial responsibility satisfactory to the director in accordance with §5.205 of this title (relating to Fees, Financial Responsibility, and Financial Assurance). | 9.1, 9.2 |
| §146.82(a)(14) | Financial Responsibility | A demonstration, satisfactory to the Director, that the applicant has met the financial responsibility requirements under § 146.85; | §5.203 (n) | Fees, financial responsibility, and financial assurance | Fees, financial responsibility, and financial assurance. The applicant must pay the fees, demonstrate that it has met the financial responsibility requirements, and provide the Commission with financial assurance as required under §5.205 of this title (relating to Fees, Financial Responsibility, and Financial Assurance). | 9.1, 9.2 |
| §146.82(a)(15) | Required class VI permit Information | Proposed testing and monitoring plan required by § 146.90; | §5.203 (h)(2) | Mechanical integrity testing | Mechanical integrity testing plan. The applicant must prepare and submit a mechanical integrity testing plan as part of a permit application. [The plan must include a schedule for the performance of a series of tests at a minimum frequency of five years.] The performance tests must be designed to demonstrate the internal and external mechanical integrity of each injection well. These tests may include: | 5.4.4 |
| §146.82(a)(16) | Required class VI permit Information | Proposed injection well plugging plan required by § 146.92(b); | §5.206 (j) | Permit Standards | Well plugging. The operator of a geologic storage facility must maintain and comply with the approved well plugging plan required by §5.203(k) of this title. | 6.1, 6.2 |
| §146.82(a)(17) | Required class VI permit Information | Proposed post-injection site care and site closure plan required by § 146.93(a); | §5.206 (k)(1) | Permit Standards | Post-injection storage facility care and closure plan. | 7.4, 7.5 |
| §146.82(a)(18) | Required class VI permit Information | At the Director's discretion, a demonstration of an alternative post-injection site care timeframe required by § 146.93(c); | §5.203(m)(8)(F) | Post-Injection storage facility carea and closure plan | an analysis must be performed to identify and assess aspects of the alternative PISC timeframe demonstration that contribute significantly to uncertainty. The operator must conduct sensitivity analyses to determine the effect that significant uncertainty may contribute to the modeling demonstration; | |
| §146.82(a)(19) | Required class VI permit Information | Proposed emergency and remedial response plan required by § 146.94(a); | §5.206 (h)(1) | Permit Standards | The operator must maintain and comply with the approved emergency and remedial response plan required by §5.203(l) of this title. The operator must update the plan in accordance with §5.207(a)(2)(D)(vi) of this title (relating to Reporting and Record-Keeping). The operator must make copies of the plan available at the storage facility and at the company headquarters. | 8.1 |

| EPA 40 CFR | CFR Category | CFR Text | 16 TAC Chapter 5 | TAC Category | Description | Permit Application |
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| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b) | Surface Map Information | Surface map and information. Only information of public record is required to be included on this map. | Intro, 3.9 |
| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b)(1) | Surface Map Information | The applicant must file with the director a surface map delineating the proposed location of any injection wells and the boundary of the geologic storage facility for which a permit is sought and the applicable AOR. | 3.8 |
| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b)(2) | Surface Map Information | The applicant must show within the AOR on the map the number or name and the location of: | |
| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b)(2)(A) | Surface Map Information | all known artificial penetrations through the confining zone, including injection wells, producing wells, inactive wells, plugged wells, or dry holes; | 3.9, Appendix B |

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| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b)(2)(B) | Surface Map Information | the locations of cathodic protection holes, subsurface cleanup sites, bodies of surface water, springs, surface and subsurface mines, quarries, and water wells; and | 3.9, Appendix B |
| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b)(2)(C) | Surface Map Information | other pertinent surface features, including pipelines, roads, and structures intended for human occupancy. | 3.9, Appendix B-3 |
| §146.82(a)(2) | Required class VI permit Information | A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84. Within the area of review, the map must show the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. Only information of public record is required to be included on this map; | §5.203 (b)(3) | Surface Map Information | The applicant must identify on the map any known or suspected faults expressed at the surface. | 3.9,N/A |
| §146.82(a)(20) | Required class VI permit Information | A list of contacts, submitted to the Director, for those States, Tribes, and Territories identified to be within the area of review of the Class VI project based on information provided in paragraph (a)(2) of this section; and | | | | Intro |
| §146.82(a)(21) | Required class VI permit Information | Any other information requested by the Director. | | | | |
| §146.82(a)(3) | Required class VI permit Information | Information on the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations, including: | §5.203 (c)(2) | Geologic, geochemical, and hydrologic information | The applicant must submit information on the geologic structure and reservoir properties of the proposed storage reservoir and overlying formations, including the following information: | |
| §146.82(a)(3)(iii) | Required class VI permit Information | Data on the depth, areal extent, thickness, mineralogy, porosity, permeability, and capillary pressure of the injection and confining zone(s); including geology/facies changes based on field data which may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions; | §5.203 (c)(2)(B) | Geologic, geochemical, and hydrologic information | The depth, areal extent, thickness, mineralogy, porosity, permeability, and capillary pressure of, and the geochemistry of any formation fluids in, the storage reservoir and confining zone and any other relevant geologic formations, including geology/facies changes based on field data, which may include geologic cores, outcrop data, seismic surveys, well logs, and lithologic descriptions, and the analyses of logging, sampling, and testing results used to make such determinations; | Section 1 |

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| §146.82(a)(4) | Required class VI permit Information | A tabulation of all wells within the area of review which penetrate the injection or confining zone(s). Such data must include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Director may require; | §5.203 (d)(1)(B) | AOR and corrective action | Identification and table of penetrations. The applicant must identify, compile, and submit a table listing all penetrations, including active, inactive, plugged, and unplugged wells and underground mines in the AOR [area of review] that may penetrate the confining zone, that are known or reasonably discoverable through specialized knowledge or experience. The applicant must provide a description of each penetration's type, construction, date drilled, location, depth, record of plugging and/or completion or closure. Examples of specialized knowledge or experience may include reviews of federal, state, and local government records, interviews with past and present owners, operators, and occupants, reviews of historical information (including aerial photographs, chain of title documents, and land use records), and visual inspections of the facility and adjoining properties. | 3.9, Appendix B |
| §146.82(a)(5) | Required class VI permit Information | Maps and stratigraphic cross sections indicating the general vertical and lateral limits of all USDWs, water wells and springs within the area of review, their positions relative to the injection zone(s), and the direction of water movement, where known; | §5.203 (c)(2)(A) | Geologic, geochemical, and hydrologic information | geologic and topographic maps and cross sections illustrating regional geology, hydrogeology, and the geologic structure of the area from the ground surface to the base of the injection zone within the AOR that indicate the general vertical and lateral limits of all USDWs within the AOR, their positions relative to the storage reservoir and the direction of water movement, where known; | 1.2.1, 1.2.2, 1.9.3 |
| §146.82(a)(5) | Required class VI permit Information | Maps and stratigraphic cross sections indicating the general vertical and lateral limits of all USDWs, water wells and springs within the area of review, their positions relative to the injection zone(s), and the direction of water movement, where known; | §5.203 (c)(2)(A) | Geologic, geochemical, and hydrologic information | Geologic and topographic maps and cross sections that indicate the general vertical and lateral limits of all USDWs within the AOR, their positions relative to the injection zone(s), and the direction of water movement, where known; | 1.2.1, 1.2.2, 1.9.3 |
| §146.82(a)(6) | Required class VI permit Information | Baseline geochemical data on subsurface formations, including all USDWs in the area of review; | §5.203 (c)(2)(G) | Geologic, geochemical, and hydrologic information | Baseline geochemical data on subsurface formations, including all formations containing USDWs in the AOR; | 1.6.2 |
| §146.82(a)(7) | Required class VI permit Information | Proposed operating data for the proposed geologic sequestration site: | §5.203 (i)(1) | Operating Information | Operating plan. The applicant must submit a plan for operating the injection wells and the geologic storage facility that complies with the criteria set forth in §5.206(d) [§5.206(c)] of this title, and that outlines the steps necessary to conduct injection operations. The applicant must include the following proposed operating data in the plan: | 4.2.6 |
| §146.82(a)(7)(i) | Required class VI permit Information | Average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the carbon dioxide stream; | §5.203 (i)(1)(A) | Operating Information | The average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the carbon dioxide stream; | 4.2.6, Intro |
| §146.82(a)(7)(ii) | Required class VI permit Information | Average and maximum injection pressure; | §5.203 (i)(1)(B) | Operating Information | The average and maximum surface injection pressure; | 4.2.6 |
| §146.82(a)(7)(iii) | Required class VI permit Information | The source(s) of the carbon dioxide stream; and | §5.203 (i)(1)(C) | Operating Information | The sources of the carbon dioxide stream and the volume of carbon dioxide from each source; and | Intro |
| §146.82(a)(7)(iv) | Required class VI permit Information | An analysis of the chemical and physical characteristics of the carbon dioxide stream. | §5.203 (i)(1)(D) | Operating Information | An analysis of the chemical and physical characteristics of the carbon dioxide stream prior to injection. | 4.2.3 |
| §146.82(a)(8) | Required class VI permit Information | Proposed pre-operational formation testing program to obtain an analysis of the chemical and physical characteristics of the injection zone(s) and confining zone(s) and that meets the requirements at § 146.87; | §5.203 (c)(2)(F) | Geologic, geochemical, and hydrologic information | a description of the formation testing program used and the analytical results used to determine the chemical and physical characteristics of the injection zone and the confining zone; and | 4.2.4.2 |
| §146.82(a)(9) | Required class VI permit Information | Proposed stimulation program, a description of stimulation fluids to be used and a determination that stimulation will not interfere with containment; | §5.203 (e)(4) | Injection well construction | Well stimulation plan. The applicant must submit, as applicable, a description of the proposed well stimulation program and a determination that stimulation will not compromise containment | 4.2.5 |
| §146.82(b) | Required class VI permit Information | The Director shall notify, in writing, any States, Tribes, or Territories within the area of review of the Class VI project based on information provided in paragraphs (a)(2) and (a)(20) of this section of the permit application and pursuant to the requirements at § 145.23(f)(13) of this chapter. | | | | |
| §146.82(c) | Required class VI permit Information | Prior to granting approval for the operation of a Class VI well, the Director shall consider the following information: | | | | |
| §146.82(c)(1) | Required class VI permit Information | The final area of review based on modeling, using data obtained during logging and testing of the well and the formation as required by paragraphs (c)(2), (3), (4), (6), (7), and (10) of this section; | | | | |

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| §146.82(c)(10) | Required class VI permit Information | Any other information requested by the Director. | | | | |
| §146.82(c)(2) | Required class VI permit Information | Any relevant updates, based on data obtained during logging and testing of the well and the formation as required by paragraphs (c)(3), (4), (6), (7), and (10) of this section, to the information on the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations, submitted to satisfy the requirements of paragraph (a)(3) of this section; | | | | |
| §146.82(c)(3) | Required class VI permit Information | Information on the compatibility of the carbon dioxide stream with fluids in the injection zone(s) and minerals in both the injection and the confining zone(s), based on the results of the formation testing program, and with the materials used to construct the well; | §5.203 (g) | Compatibility determination | Compatibility determination. Based on the results of the formation testing program required by subsection (f) of this section, the applicant must submit a determination of the compatibility of the CO2 stream with: | |
| §146.82(c)(3) | Required class VI permit Information | Information on the compatibility of the carbon dioxide stream with fluids in the injection zone(s) and minerals in both the injection and the confining zone(s), based on the results of the formation testing program, and with the materials used to construct the well; | §5.203 (g)(1) | Compatibility determination | the materials to be used to construct the well; | 4.2.1, Appendix D |
| §146.82(c)(3) | Required class VI permit Information | Information on the compatibility of the carbon dioxide stream with fluids in the injection zone(s) and minerals in both the injection and the confining zone(s), based on the results of the formation testing program, and with the materials used to construct the well; | §5.203 (g)(2) | Compatibility determination | fluids in the injection zone; and | 1.6.3 |
| §146.82(c)(3) | Required class VI permit Information | Information on the compatibility of the carbon dioxide stream with fluids in the injection zone(s) and minerals in both the injection and the confining zone(s), based on the results of the formation testing program, and with the materials used to construct the well; | §5.203 (g)(3) | Compatibility determination | minerals in both the injection and the confining zone. | 1.6.3 |
| §146.82(c)(4) | Required class VI permit Information | The results of the formation testing program required at paragraph (a)(8) of this section; | | | | |
| §146.82(c)(5) | Required class VI permit Information | Final injection well construction procedures that meet the requirements of § 146.86; | | | | |
| §146.82(c)(6) | Required class VI permit Information | The status of corrective action on wells in the area of review; | | | | |
| §146.82(c)(7) | Required class VI permit Information | All available logging and testing program data on the well required by § 146.87; | | | | |
| §146.82(c)(8) | Required class VI permit Information | A demonstration of mechanical integrity pursuant to § 146.89; | | | | |
| §146.82(c)(9) | Required class VI permit Information | Any updates to the proposed area of review and corrective action plan, testing and monitoring plan, injection well plugging plan, post-injection site care and site closure plan, or the emergency and remedial response plan submitted under paragraph (a) of this section, which are necessary to address new information collected during logging and testing of the well and the formation as required by all paragraphs of this section, and any updates to the alternative post-injection site care timeframe demonstration submitted under paragraph (a) of this section, which are necessary to address new information collected during the logging and testing of the well and the formation as required by all paragraphs of this section; and | | | | |
| §146.82(d) | Required class VI permit Information | Owners or operators seeking a waiver of the requirement to inject below the lowermost USDW must also refer to § 146.95 and submit a supplemental report, as required at § 146.95(a). The supplemental report is not part of the permit application. | §5.201 (f) | Applicability and compliance | Injection depth waiver. An operator may seek a waiver from the Class VI injection depth requirements for geologic storage to allow injection into non-USDW formations while ensuring that USDWs above and below the injection zone are protected from endangerment. An operator seeking a waiver of the requirement to inject below the lowermost USDW shall submit, concurrent with the permit application, a supplemental report that complies with 40 21 CFR §146.95. The Commission adopts 40 CFR §146.95 by reference, effective July 1, 2022. | |

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| §146.83(a) | Minimum Criteria for siting | Owners or operators of Class VI wells must demonstrate to the satisfaction of the Director that the wells will be sited in areas with a suitable geologic system. The owners or operators must demonstrate that the geologic system comprises: | §5.206 (b)(5) | General Criteria | the geologic storage facility will be sited in an area with suitable geology, which at a minimum must include: | |
| §146.83(a)(1) | Minimum Criteria for siting | An injection zone(s) of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream; | §5.206 (b)(5)(A) | General Criteria | An injection zone(s) of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream; | 1.9.4 |
| §146.83(a)(2) | Minimum Criteria for siting | Confining zone(s) free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zone(s). | §5.206 (b)(5)(B) | General Criteria | Confining zone(s) free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zone(s). | 1.4.2 |
| §146.83(b) | Minimum Criteria for siting | The Director may require owners or operators of Class VI wells to identify and characterize additional zones that will impede vertical fluid movement, are free of faults and fractures that may interfere with containment, allow for pressure dissipation, and provide additional opportunities for monitoring, mitigation, and remediation. | | | | |
| §146.84 | Area of review and corrective action | | §5.203 (d) | AOR and corrective action | Area of Review and Corrective Action | Section 3 |
| §146.84(a) | Area of review and corrective action | The area of review is the region surrounding the geologic sequestration project where USDWs may be endangered by the injection activity. The area of review is delineated using computational modeling that accounts for the physical and chemical properties of all phases of the injected carbon dioxide stream and is based on available site characterization, monitoring, and operational data. | §5.203 (d) | AOR and corrective action | This subsection describes the standards for the information regarding the delineation of the AOR, the identification of penetrations, and corrective action that an applicant must include in an application. | Section 3 |
| §146.84(a) | Area of review and corrective action | The area of review is the region surrounding the geologic sequestration project where USDWs may be endangered by the injection activity. The area of review is delineated using computational modeling that accounts for the physical and chemical properties of all phases of the injected carbon dioxide stream and is based on available site characterization, monitoring, and operational data. | §5.203 (d)(1)(A)(ii)(IV) | AOR and corrective action | considers the physical and chemical properties of injected and formation fluids; and | 3.3 |
| §146.84(b) | Area of review and corrective action | The owner or operator of a Class VI well must prepare, maintain, and comply with a plan to delineate the area of review for a proposed geologic sequestration project, periodically reevaluate the delineation, and perform corrective action that meets the requirements of this section and is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. As a part of the permit application for approval by the Director, the owner or operator must submit an area of review and corrective action plan that includes the following information: | §5.203 (d)(1) | AOR and corrective action | Initial delineation of the AOR and initial corrective action. The applicant must delineate the AOR, identify all wells that require corrective action, and perform corrective action on those wells. Corrective action may be phased. | 3.10 |
| §146.84(b)(1) | Area of review and corrective action | The method for delineating the area of review that meets the requirements of paragraph (c) of this section, including the model to be used, assumptions that will be made, and the site characterization data on which the model will be based; | §5.203 (d)(2)(A) | AOR and corrective action | The method for delineating the AOR, including the model to be used, assumptions that will be made, and the site characterization data on which the model will be based; | 3.2, 3.3, 3.4 |
| §146.84(b)(2) | Area of review and corrective action | A description of: | §5.203 (d)(2)(B) | AOR and corrective action | For AOR, a description of: | |
| §146.84(b)(2)(i) | Area of review and corrective action | The minimum fixed frequency, not to exceed five years, at which the owner or operator proposes to reevaluate the area of review; | §5.203 (d)(2)(B)(i) | AOR and corrective action | the minimum frequency subject to the annual certification pursuant to §5.206(f) of this title (relating to Permit Standards) at which the applicant proposes to re-evaluate the AOR during the life of the geologic storage facility; | 3.11.1 |

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| §146.84(b)(2)(ii) | Area of review and corrective action | The monitoring and operational conditions that would warrant a reevaluation of the area of review prior to the next scheduled reevaluation as determined by the minimum fixed frequency established in paragraph (b)(2)(i) of this section. | §5.203 (d)(2)(B)(iii) | AOR and corrective action | the monitoring and operational conditions that would warrant a re-evaluation of the AOR prior to the next scheduled re-evaluation; and | 3.11.1 |
| §146.84(b)(2)(iii) | Area of review and corrective action | How monitoring and operational data (e.g., injection rate and pressure) will be used to inform an area of review reevaluation; and | §5.203 (d)(2)(B)(ii) | AOR and corrective action | How monitoring and operational data (e.g., injection rate and pressure) will be used to inform an area of review reevaluation; and | 3.11.1 |
| §146.84(b)(2)(iv) | Area of review and corrective action | How corrective action will be conducted to meet the requirements of paragraph (d) of this section, including what corrective action will be performed prior to injection and what, if any, portions of the area of review will have corrective action addressed on a phased basis and how the phasing will be determined; how corrective action will be adjusted if there are changes in the area of review; and how site access will be guaranteed for future corrective action. | §5.203 (d)(2)(C) | AOR and corrective action | a corrective action plan that describes: | |
| §146.84(b)(2)(iv) | Area of review and corrective action | How corrective action will be conducted to meet the requirements of paragraph (d) of this section, including what corrective action will be performed prior to injection and what, if any, portions of the area of review will have corrective action addressed on a phased basis and how the phasing will be determined; how corrective action will be adjusted if there are changes in the area of review; and how site access will be guaranteed for future corrective action. | §5.203 (d)(2)(C)(i) | AOR and corrective action | how the corrective action will be conducted; | 3.11.1 |
| §146.84(b)(2)(iv) | Area of review and corrective action | How corrective action will be conducted to meet the requirements of paragraph (d) of this section, including what corrective action will be performed prior to injection and what, if any, portions of the area of review will have corrective action addressed on a phased basis and how the phasing will be determined; how corrective action will be adjusted if there are changes in the area of review; and how site access will be guaranteed for future corrective action. | §5.203 (d)(2)(C)(ii) | AOR and corrective action | how corrective action will be adjusted if there are changes in the AOR; | 3.11.1 |
| §146.84(b)(2)(iv) | Area of review and corrective action | How corrective action will be conducted to meet the requirements of paragraph (d) of this section, including what corrective action will be performed prior to injection and what, if any, portions of the area of review will have corrective action addressed on a phased basis and how the phasing will be determined; how corrective action will be adjusted if there are changes in the area of review; and how site access will be guaranteed for future corrective action. | §5.203 (d)(2)(C)(iii) | AOR and corrective action | if a phased corrective action is planned, how the phasing will be determined; and | 3.11.1 |
| §146.84(b)(2)(iv) | Area of review and corrective action | How corrective action will be conducted to meet the requirements of paragraph (d) of this section, including what corrective action will be performed prior to injection and what, if any, portions of the area of review will have corrective action addressed on a phased basis and how the phasing will be determined; how corrective action will be adjusted if there are changes in the area of review; and how site access will be guaranteed for future corrective action. | §5.203 (d)(2)(C)(iv) | AOR and corrective action | how site access will be secured for future corrective action. | 3.11.1 |
| §146.84(c) | Area of review and corrective action | Owners or operators of Class VI wells must perform the following actions to delineate the area of review and identify all wells that require corrective action: | | | | |

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| §146.84(c)(1) | Area of review and corrective action | Predict, using existing site characterization, monitoring and operational data, and computational modeling, the projected lateral and vertical migration of the carbon dioxide plume and formation fluids in the subsurface from the commencement of injection activities until the plume movement ceases, until pressure differentials sufficient to cause the movement of injected fluids or formation fluids into a USDW are no longer present, or until the end of a fixed time period as determined by the Director. The model must: | §5.203 (d)(1)(A)(i) | AOR and corrective action | Using computational modeling that considers the volumes and the physical and chemical properties of the injected CO2 stream, the physical properties of the formation into which the CO2 stream is to be injected, and available data including data available from logging, testing, or operation of wells, the applicant must predict the lateral and vertical extent of migration for the CO2 plume and formation fluids and the pressure differentials required to cause movement of injected fluids or formation fluids into a USDW in the subsurface for the following time periods: | |
| §146.84(c)(1) | Area of review and corrective action | Predict, using existing site characterization, monitoring and operational data, and computational modeling, the projected lateral and vertical migration of the carbon dioxide plume and formation fluids in the subsurface from the commencement of injection activities until the plume movement ceases, until pressure differentials sufficient to cause the movement of injected fluids or formation fluids into a USDW are no longer present, or until the end of a fixed time period as determined by the Director. The model must: | §5.203 (d)(1)(A)(i)(II) | AOR and corrective action | five years after initiation of injection; | 2.3.3 |
| §146.84(c)(1) | Area of review and corrective action | Predict, using existing site characterization, monitoring and operational data, and computational modeling, the projected lateral and vertical migration of the carbon dioxide plume and formation fluids in the subsurface from the commencement of injection activities until the plume movement ceases, until pressure differentials sufficient to cause the movement of injected fluids or formation fluids into a USDW are no longer present, or until the end of a fixed time period as determined by the Director. The model must: | §5.203 (d)(1)(A)(i)(III) | AOR and corrective action | from initiation of injection to the end of the injection period proposed by the applicant; and | 2.3.3 |
| §146.84(c)(1) | Area of review and corrective action | Predict, using existing site characterization, monitoring and operational data, and computational modeling, the projected lateral and vertical migration of the carbon dioxide plume and formation fluids in the subsurface from the commencement of injection activities until the plume movement ceases, until pressure differentials sufficient to cause the movement of injected fluids or formation fluids into a USDW are no longer present, or until the end of a fixed time period as determined by the Director. The model must: | §5.203 (d)(1)(A)(i)(III) | AOR and corrective action | from initiation of injection until the plume movement ceases, for a minimum of [to] 10 years after the end of the injection period proposed by the applicant. | 2.3.3, 2.4 |
| §146.84(c)(1) | Area of review and corrective action | Predict, using existing site characterization, monitoring and operational data, and computational modeling, the projected lateral and vertical migration of the carbon dioxide plume and formation fluids in the subsurface from the commencement of injection activities until the plume movement ceases, until pressure differentials sufficient to cause the movement of injected fluids or formation fluids into a USDW are no longer present, or until the end of a fixed time period as determined by the Director. The model must: | §5.203 (d)(1)(A)(ii) | AOR and corrective action | The applicant must use a computational model that: | |
| §146.84(c)(1)(i) | Area of review and corrective action | Be based on detailed geologic data collected to characterize the injection zone(s), confining zone(s) and any additional zones; and anticipated operating data, including injection pressures, rates, and total volumes over the proposed life of the geologic sequestration project; | §5.203 (d)(1)(A)(ii)(I) | AOR and corrective action | Is based on geologic and reservoir engineering information collected to characterize the injection zone and the confining zone | 2.2.1.1, 2.2.2, 2.2.3, 2.2.4 |
| §146.84(c)(1)(i) | Area of review and corrective action | Be based on detailed geologic data collected to characterize the injection zone(s), confining zone(s) and any additional zones; and anticipated operating data, including injection pressures, rates, and total volumes over the proposed life of the geologic sequestration project; | §5.203 (d)(1)(A)(ii)(II) | AOR and corrective action | is based on anticipated operating data, including injection pressures, rates, temperatures, and total volumes and/or mass over the proposed duration of injection; | 2.2.4, 2.2.5 |

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| §146.84(c)(1)(ii) | Area of review and corrective action | Take into account any geologic heterogeneities, other discontinuities, data quality, and their possible impact on model predictions; and | §5.203 (d)(1)(A)(ii)(III) | AOR and corrective action | Take into account any geologic heterogeneities, other discontinuities, data quality, and their possible impact on model predictions; and | 2.2.1, 2.2.2, 2.3.1 |
| §146.84(c)(1)(iii) | Area of review and corrective action | Consider potential migration through faults, fractures, and artificial penetrations. | §5.203 (d)(1)(A)(ii)(V) | AOR and corrective action | Considers potential migration through known faults, fractures, and artificial penetrations and beyond lateral spill points. | 1.4.2 |
| §146.84(c)(2) | Required class VI permit Information | Using methods approved by the Director, identify all penetrations, including active and abandoned wells and underground mines, in the area of review that may penetrate the confining zone(s). Provide a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Director may require; and | §5.203 (d)(1)(B) | AOR and corrective action | Identification and table of penetrations. The applicant must identify, compile, and submit a table listing all penetrations, including active, inactive, plugged, and unplugged wells and underground mines in the AOR [area of review] that may penetrate the confining zone, that are known or reasonably discoverable through specialized knowledge or experience. The applicant must provide a description of each penetration's type, construction, date drilled or excavated, location, depth, and record of plugging and/or completion or closure. Examples of specialized knowledge or experience may include reviews of federal, state, and local government records, interviews with past and present owners, operators, and occupants, reviews of historical information (including aerial photographs, chain of title documents, and land use records), and visual inspections of the facility and adjoining properties. | 3.9 N/A |
| §146.84(c)(3) | Area of review and corrective action | Determine which abandoned wells in the area of review have been plugged in a manner that prevents the movement of carbon dioxide or other fluids that may endanger USDWs, including use of materials compatible with the carbon dioxide stream. | §5.203 (d)(1)(C) | AOR and corrective action | Corrective action. The applicant must demonstrate whether each of the wells on the table of penetrations has or has not been plugged and whether each of the underground mines (if any) on the table of penetrations has or has not been closed in a manner that prevents the movement of injected fluids or displaced formation fluids that may endanger USDWs or allow the injected fluids or formation fluids to escape the permitted injection zone. The applicant must perform corrective action on all wells and underground mines in the AOR that are determined to need corrective action. The operator must perform corrective action using materials suitable for use with the CO2 stream. Corrective action may be phased. | 3.9 N/A |
| §146.84(d) | Area of review and corrective action | Owners or operators of Class VI wells must perform corrective action on all wells in the area of review that are determined to need corrective action, using methods designed to prevent the movement of fluid into or between USDWs, including use of materials compatible with the carbon dioxide stream, where appropriate. | §5.203 (d)(1)(C) | AOR and corrective action | Corrective action. The applicant must demonstrate whether each of the wells on the table of penetrations has or has not been plugged and whether each of the underground mines (if any) on the table of penetrations has or has not been closed in a manner that prevents the movement of injected fluids or displaced formation fluids that may endanger USDWs or allow the injected fluids or formation fluids to escape the permitted injection zone. The applicant must perform corrective action on all wells and underground mines in the AOR that are determined to need corrective action. The operator must perform corrective action using materials suitable for use with the CO2 stream. Corrective action may be phased. | 3.9 N/A |
| §146.84(e) | Area of review and corrective action | At the minimum fixed frequency, not to exceed five years, as specified in the area of review and corrective action plan, or when monitoring and operational conditions warrant, owners or operators must: | §5.206 (g) | AOR and corrective action | Area of review and corrective action. Notwithstanding the requirement in §5.203(d)(2)(B)(i) of 30 this title to perform a re-evaluation of the AOR, at the fixed frequency specified in the area of review and corrective action plan or permit, the operator of a geologic storage facility also must conduct the following whenever warranted by a material change in the monitoring and/or operational data or in the evaluation of the monitoring and operational data by the operator: | 3.11.1 |
| §146.84(e)(1) | Area of review and corrective action | Reevaluate the area of review in the same manner specified in paragraph (c)(1) of this section; | §5.206 (g)(1) | AOR and corrective action | a re-evaluation of the AOR [area of review] by performing all of the actions specified in §5.203(d)(1)(A) - (C) of this title to delineate the AOR [area of review] and identify all wells that require corrective action; | |
| §146.84(e)(2) | Area of review and corrective action | Identify all wells in the reevaluated area of review that require corrective action in the same manner specified in paragraph (c) of this section; | §5.206 (g)(2) | AOR and corrective action | Identify all wells in the reevaluated area of review that require corrective action; and | 3.11.1 |

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| §146.84(e)(3) | Area of review and corrective action | Perform corrective action on wells requiring corrective action in the reevaluated area of review in the same manner specified in paragraph (d) of this section; and | §5.206 (g)(3) | AOR and corrective action | Perform corrective action on wells requiring corrective action in the reevaluated area of review in the same manner specified in §5.203(d)(1)(C) of this title; and | |
| §146.84(e)(4) | Area of review and corrective action | Submit an amended area of review and corrective action plan or demonstrate to the Director through monitoring data and modeling results that no amendment to the area of review and corrective action plan is needed. Any amendments to the area of review and corrective action plan must be approved by the Director, must be incorporated into the permit, and are subject to the permit modification requirements at § 144.39 or § 144.41 of this chapter, as appropriate. | §5.206 (g)(4) | AOR and corrective action | Submit an amended area of review and corrective action plan or demonstrate to the Director through monitoring data and modeling results that no amendment to the area of review and corrective action plan is needed. | |
| §146.84(f) | Financial Responsibility | The emergency and remedial response plan (as required by § 146.94) and the demonstration of financial responsibility (as described by § 146.85) must account for the area of review delineated as specified in paragraph (c)(1) of this section or the most recently evaluated area of review delineated under paragraph (e) of this section, regardless of whether or not corrective action in the area of review is phased. | §5.205 (b)(3) | Fees, financial responsibility, and financial assurance | The applicant's demonstration of financial responsibiltiy must account for the entire AOR, regardless of whether corrective action in the AOR is phased. | 9.2 |
| §146.84(g) | Area of review and corrective action | All modeling inputs and data used to support area of review reevaluations under paragraph (e) of this section shall be retained for 10 years. | | | | 3.7 |
| §146.85 | Financial Responsibility | | §5.205 (b)(1) | Fees, financial responsibility, and financial assurance | A person to whom a permit is issued under this subchapter must provide annually to the director evidence of financial responsibility that is satisfactory to the director. The operator must demonstrate and maintain financial responsibility and resources for corrective action, injection well plugging, post-injection storage facility care and storage facility closure, and emergency and remedial response until the director has provided written verification that the director has determined that the facility has reached the end of the post-injection storage facility care period. | 9.1 |
| §146.85 | Financial Responsibility | | §5.205 (b)(2) | Fees, financial responsibility, and financial assurance | In determining whether the person is financially responsible, the director must rely on: | |
| §146.85 | Financial Responsibility | | §5.205 (b)(2)(A) | Fees, financial responsibility, and financial assurance | the person's most recent audited annual report 1 filed with the U. S. Securities and Exchange Commission under Section 13 or 15(d), Securities Exchange Act of 1934 (15 U.S.C. Section 78m or 78o(d)); and | 9.1 |
| §146.85 | Financial Responsibility | | §5.205 (b)(2)(B) | Fees, financial responsibility, and financial assurance | the person's most recent quarterly report filed with the U. S. Securities and Exchange Commission under Section 13 or 15(d), Securities Exchange Act of 1934 (15 U.S.C. Section 78m or 78o(d)); or | 9.1 |
| §146.85 | Financial Responsibility | | §5.205 (b)(2)(C) | Fees, financial responsibility, and financial assurance | if the person is not required to file such a report, the person's most recent audited financial statement. The date of the audit must not be more than one year before the date of submission of the application to the director. | 9.1 |
| §146.85 | Financial Responsibility | | §5.205 (b)(3) | Fees, financial responsibility, and financial assurance | The applicant's demonstratio of financial responsibiltiy must account for the entire AOR, regardless of whether corrective action in the AOR is phased. | 9.1 |
| §146.85 | | | §5.205 (c) | Financial assurance | Financial assurance. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(1) | Fees, financial responsibility, and financial assurance | Injection and monitoring wells. The operator must comply with the requirements of §3.78 of this title for all monitoring wells that penetrate the base of usable quality water and this subsection for all injection wells. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2) | Fees, financial responsibility, and financial assurance | Geologic storage facility. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(A) | Fees, financial responsibility, and financial assurance | The applicant must include in an application for a geologic storage facility permit: | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(A)(iii) | Fees, financial responsibility, and financial assurance | information concerning the issuer of the bond or letter of credit including the issuer's name and address and evidence of authority to issue bonds or letters of credit in Texas. | |

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| §146.85 | Financial Responsibility | | §5.205 (c)(2)(B) | Fees, financial responsibility, and financial assurance | A geologic storage facility shall not receive CO2 until a bond or letter of credit in an amount approved by the director under this subsection and meeting the requirements of this subsection as to form and issuer has been filed with and approved by the director. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(C) | Fees, financial responsibility, and financial assurance | The determination of the amount of financial assurance for a geologic storage facility is subject to the following requirements: | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(C)(ii) | Fees, financial responsibility, and financial assurance | A qualified professional engineer licensed by the State of Texas, as required under Occupations Code, Chapter 1001, relating to Texas Engineering Practice Act, must prepare or supervise the preparation of a written estimate of the highest likely amount necessary to close the geologic storage facility. The operator must submit to the director the written estimate under seal of a qualified licensed professional engineer, as required under Occupations Code, Chapter 1001, relating to Texas Engineering Practice Act; and | Cover sheets |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(C)(iii) | Fees, financial responsibility, and financial assurance | The Commission may use the proceeds of financial assurance filed under this subsection to pay the costs of plugging any well or wells at the facility if the financial assurance for plugging costs filed with the Commission is insufficient to pay for the plugging of such well or wells. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(D) | Financial assurance | Bonds and letters of credit filed in satisfaction of the financial assurance requirements for a geologic storage facility must comply with the following standards as to issuer and form. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(D)(i) | Financial assurance | The issuer of any geologic storage facility bond filed in satisfaction of the requirements of this subsection must be a corporate surety authorized to do business in Texas. The form of bond filed under this subsection must provide that the bond be renewed and continued in effect until the conditions of the bond have been met or its release is authorized by the director. | Cover sheets |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(D)(ii) | Financial assurance | Any letter of credit filed in satisfaction of the requirements of this subsection must be issued by and drawn on a bank authorized under state or federal law to operate in Texas. The letter of credit must be an irrevocable, standby letter of credit subject to the requirements of Texas Business and Commerce Code, §§5.101 - 5.118. The letter of credit must provide that it will be renewed and continued in effect until the conditions of the letter of credit have been met or its release is authorized by the director. | |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(D) | Fees, financial responsibility, and financial assurance | Bonds and letters of credit filed in satisfaction of the financial assurance requirements for a geologic storage facility must comply with the following standards as to issuer and form. | |
| §146.85 | Financial Responsibility | | §5.205 (c) | Fees, financial responsibility, and financial assurance | Financial assurance. | 9.1 |
| §146.85 | Financial Responsibility | | §5.205 (c)(2)(A)(ii) | Fees, financial responsibility, and financial assurance | a copy of the form of the bond or letter of credit that will be filed with the Commission; and | TBD |
| §146.85(a)(2) | Financial Responsibility | | §5.205 (c)(2)(C)(i) | Fees, financial responsibility, and financial assurance | The director must approve the dollar amount of the financial assurance. The amount of financial assurance required to be filed under this subsection must be equal to or greater than the maximum amount necessary to perform corrective action, emergency response, and remedial action, post-injection monitoring and site care, and closure of the geologic storage facility at any time during the permit term in accordance with all applicable state laws, Commission rules and orders, and the permit; | 9.2, 9.3 |
| §146.85(a)(2)(i) | Financial Responsibility | | §5.205 (c)(2)(A)(i) | Fees, financial responsibility, and financial assurance | a written estimate of the highest likely dollar amount necessary to perform post-injection monitoring and closure of the facility that shows all assumptions and calculations used to develop the estimate; | 9.6.1 |

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| §146.85(a)(4)(i)(A) | | | §5.205 (d)(3) | Nodtice of adverse financial conditions | Upon the incapacity of a bank or surety company by reason of bankruptcy, insolvency or suspension, or revocation of its charter or license, the Commission must deem the operator to be without bond coverage. The Commission must issue a notice to any operator who is without bond coverage and must specify a reasonable period to replace bond coverage, not to exceed 60 days. | |
| §146.85(c) | Financial Responsibility | | §5.205 (c)(2)(A)(i) | Financial assurance | a written estimate of the highest likely dollar amount necessary to perform post-injection monitoring and closure of the facility that shows all assumptions and calculations used to develop the estimate; | 9.6.1 |
| §146.85(c) | Financial Responsibility | | §5.205 (c)(2)(C)(i) | Financial assurance | The director must approve the dollar amount of the financial assurance. The amount of financial assurance required to be filed under this subsection must be equal to or greater than the maximum amount necessary to perform corrective action, emergency response, and remedial action, post-injection monitoring and site care, and closure of the geologic storage facility at any time during the permit term in accordance with all applicable state laws, Commission rules and orders, and the permit; | 9.2, 9.3 |
| §146.85(c) | Financial Responsibility | | §5.205 (c)(2)(E) | Fees, financial responsibility, and financial assurance | The operator of a geologic storage facility must provide to the director annual written updates of the cost estimate to increase or decrease the cost estimate to account for any changes to the AOR and corrective action plan, the emergency response and remedial action plan, the injection well plugging plan, and the post-injection storage facility care and closure plan. The operator must provide to the director upon request an adjustment of the cost estimate if the director has reason to believe that the original demonstration is no longer adequate to cover the cost of injection well plugging and post-injection storage facility care and closure. | 9.1, 9.8 |
| §146.85(c) | Financial Responsibility | | §5.205 (c)(3) | Fees, financial responsibility, and financial assurance | The director may consider allowing the phasing in of financial assurance for only corrective action based on project-specific factors. | |
| §146.85(c)(2) | Financial Responsibility | | §5.205 (c)(2)(E) | Financial assurance | The operator of a geologic storage facility must provide to the director annual written updates of the cost estimate to increase or decrease the cost estimate to account for any changes to the AOR and corrective action plan, the emergency response and remedial action plan, the injection well plugging plan, and the post-injection storage facility care and closure plan. The operator must provide to the director upon request an adjustment of the cost estimate if the director has reason to believe that the original demonstration is no longer adequate to cover the cost of injection well plugging and post-injection storage facility care and closure. | 9.1, 9.8 |
| §146.85(c)(3) | Financial Responsibility | | §5.205 (c)(4) | Fees, financial responsibility, and financial assurance | The director may approve a reduction in the amount of financial assurance required for post-injection monitoring and/or corrective action based on project-specific monitoring results. | |
| §146.85(d) | Financial Responsibility | | §5.205 (D) | Fees, financial responsibility, and financial assurance | Notice of adverse financial conditions | |
| §146.85(d) | Financial Responsibility | | §5.205 (D)(1) | Fees, financial responsibility, and financial assurance | The operator must notify the Commission of adverse financial conditions that may affect the operator's ability to carry out injection well plugging and post-injection storage facility care and closure. An operator must file any notice of bankruptcy in accordance with §3.1(f) of this title (relating to Organization Report; Retention of Records; Notice Requirements). The operator must give such notice by certified mail. | 9.2 |
| §146.85(d) | Financial Responsibility | | §5.205 (D)(2) | Fees, financial responsibility, and financial assurance | The operator filing a bond must ensure that the bond provides a mechanism for the bond or surety company to give prompt notice to the Commission and the operator of any action filed alleging insolvency or bankruptcy of the surety company or the bank or alleging any violation that would result in suspension or revocation of the surety or bank's charter or license to do business. | |

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| §146.85(d) | Financial Responsibility | | §5.205 (D)(3) | Fees, financial responsibility, and financial assurance | Upon the incapacity of a bank or surety company by reason of bankruptcy, insolvency or suspension, or revocation of its charter or license, the Commission must deem the operator to be without bond coverage. The Commission must issue a notice to any operator who is without bond coverage and must specify a reasonable period to replace bond coverage, not to exceed 60 days. | |
| §146.85(a) | Financial Responsibility | The owner or operator must demonstrate and maintain financial responsibility as determined by the Director that meets the following conditions: | | | | |
| §146.85(a)(1) | | The financial responsibility instrument(s) used must be from the following list of qualifying instruments: | | | | |
| §146.85(a)(1)(i) | | Trust Funds. | | | | |
| §146.85(a)(1)(ii) | | Surety Bonds. | | | | 9.2 |
| §146.85(a)(1)(iii) | | Letter of Credit. | | | | |
| §146.85(a)(1)(iv) | | Insurance | | | | 9.2 |
| §146.85(a)(1)(v) | | Self Insurance (i.e., Financial Test and Corporate Guarantee). | | | | |
| §146.85(a)(1)(vi) | | Escrow Account | | | | |
| §146.85(a)(1)(vii) | | Any other instrument(s) satisfactory to the Director. | | | | |
| §146.85(a)(2) | | The qualifying instrument(s) must be sufficient to cover the cost of: | | | | |
| §146.85(a)(2)(i) | | Corrective action (that meets the requirements of § 146.84); | | | | 9.3 |
| §146.85(a)(2)(ii) | | Injection well plugging (that meets the requirements of § 146.92); | | | | 9.4 |
| §146.85(a)(2)(iii) | | Post injection site care and site closure (that meets the requirements of § 146.93); and | | | | 9.6 |
| §146.85(a)(2)(iv) | | Emergency and remedial response (that meets the requirements of § 146.94). | | | | 9.7 |
| §146.85(a)(3) | | The financial responsibility instrument(s) must be sufficient to address endangerment of underground sources of drinking water. | | | | 9.7.2 |
| §146.85(a)(4) | | The qualifying financial responsibility instrument(s) must comprise protective conditions of coverage. | | | | |
| §146.85(a)(4)(i) | | Protective conditions of coverage must include at a minimum cancellation, renewal, and continuation provisions, specifications on when the provider becomes liable following a notice of cancellation if there is a failure to renew with a new qualifying financial instrument, and requirements for the provider to meet a minimum rating, minimum capitalization, and ability to pass the bond rating when applicable. | | | | 9.2 |
| §146.85(a)(4)(i)(A) | | Cancellation - for purposes of this part, an owner or operator must provide that their financial mechanism may not cancel, terminate or fail to renew except for failure to pay such financial instrument. If there is a failure to pay the financial instrument, the financial institution may elect to cancel, terminate, or fail to renew the instrument by sending notice by certified mail to the owner or operator and the Director. The cancellation must not be final for 120 days after receipt of cancellation notice. The owner or operator must provide an alternate financial responsibility demonstration within 60 days of notice of cancellation, and if an alternate financial responsibility demonstration is not acceptable (or possible), any funds from the instrument being cancelled must be released within 60 days of notification by the Director. | | | | |

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| §146.85(a)(4)(i)(B) | | Renewal - for purposes of this part, owners or operators must renew all financial instruments, if an instrument expires, for the entire term of the geologic sequestration project. The instrument may be automatically renewed as long as the owner or operator has the option of renewal at the face amount of the expiring instrument. The automatic renewal of the instrument must, at a minimum, provide the holder with the option of renewal at the face amount of the expiring financial instrument. | | | | |
| §146.85(a)(4)(i)(C) | | Cancellation, termination, or failure to renew may not occur and the financial instrument will remain in full force and effect in the event that on or before the date of expiration: The Director deems the facility abandoned; or the permit is terminated or revoked or a new permit is denied; or closure is ordered by the Director or a U.S. district court or other court of competent jurisdiction; or the owner or operator is named as debtor in a voluntary or involuntary proceeding under Title 11 (Bankruptcy), U.S. Code; or the amount due is paid. | | | | |
| §146.85(a)(5) | | The qualifying financial responsibility instrument(s) must be approved by the Director. | | | | |
| §146.85(a)(5)(i) | | The Director shall consider and approve the financial responsibility demonstration for all the phases of the geologic sequestration project prior to issue a Class VI permit (§ 146.82). | | | | |
| §146.85(a)(5)(ii) | | The owner or operator must provide any updated information related to their financial responsibility instrument(s) on an annual basis and if there are any changes, the Director must evaluate, within a reasonable time, the financial responsibility demonstration to confirm that the instrument(s) used remain adequate for use. The owner or operator must maintain financial responsibility requirements regardless of the status of the Director's review of the financial responsibility demonstration. | | | | 9.2 |
| §146.85(a)(5)(iii) | | The Director may disapprove the use of a financial instrument if he determines that it is not sufficient to meet the requirements of this section. | | | | |
| §146.85(a)(6) | | The owner or operator may demonstrate financial responsibility by using one or multiple qualifying financial instruments for specific phases of the geologic sequestration project. | | | | |
| §146.85(a)(6)(i) | | In the event that the owner or operator combines more than one instrument for a specific geologic sequestration phase (e.g., well plugging), such combination must be limited to instruments that are not based on financial strength or performance (i.e., self insurance or performance bond), for example trust funds, surety bonds guaranteeing payment into a trust fund, letters of credit, escrow account, and insurance. In this case, it is the combination of mechanisms, rather than the single mechanism, which must provide financial responsibility for an amount at least equal to the current cost estimate. | | | | |
| §146.85(a)(6)(ii) | | When using a third-party instrument to demonstrate financial responsibility, the owner or operator must provide a proof that the third-party providers either have passed financial strength requirements based on credit ratings; or has met a minimum rating, minimum capitalization, and ability to pass the bond rating when applicable. | | | | |

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| §146.85(a)(6)(iii) | | An owner or operator using certain types of third-party instruments must establish a standby trust to enable EPA to be party to the financial responsibility agreement without EPA being the beneficiary of any funds. The standby trust fund must be used along with other financial responsibility instruments (e.g., surety bonds, letters of credit, or escrow accounts) to provide a location to place funds if needed. | | | | |
| §146.85(a)(6)(iv) | | An owner or operator may deposit money to an escrow account to cover financial responsibility requirements; this account must segregate funds sufficient to cover estimated costs for Class VI (geologic sequestration) financial responsibility from other accounts and uses. | | | | |
| §146.85(a)(6)(v) | | An owner or operator or its guarantor may use self insurance to demonstrate financial responsibility for geologic sequestration projects. In order to satisfy this requirement the owner or operator must meet a Tangible Net Worth of an amount approved by the Director, have a Net working capital and tangible net worth each at least six times the sum of the current well plugging, post injection site care and site closure cost, have assets located in the United States amounting to at least 90 percent of total assets or at least six times the sum of the current well plugging, post injection site care and site closure cost, and must submit a report of its bond rating and financial information annually. In addition the owner or operator must either: Have a bond rating test of AAA, AA, A, or BBB as issued by Standard & Poor's or Aaa, Aa, A, or Baa as issued by Moody's; or meet all of the following five financial ratio thresholds: A ratio of total liabilities to net worth less than 2.0; a ratio of current assets to current liabilities greater than 1.5; a ratio of the sum of net income plus depreciation, depletion, and amortization to total liabilities greater than 0.1; A ratio of current assets minus current liabilities to total assets greater than −0.1; and a net profit (revenues minus expenses) greater than 0. | | | | |
| §146.85(a)(6)(vi) | | An owner or operator who is not able to meet corporate financial test criteria may arrange a corporate guarantee by demonstrating that its corporate parent meets the financial test requirements on its behalf. The parent's demonstration that it meets the financial test requirement is insufficient if it has not also guaranteed to fulfill the obligations for the owner or operator. | | | | |
| §146.85(a)(6)(vii) | | An owner or operator may obtain an insurance policy to cover the estimated costs of geologic sequestration activities requiring financial responsibility. This insurance policy must be obtained from a third party provider. | | | | 9.2 |
| §146.85(b) | | The requirement to maintain adequate financial responsibility and resources is directly enforceable regardless of whether the requirement is a condition of the permit. | | | | |
| §146.85(b)(1) | | The owner or operator must maintain financial responsibility and resources until: | | | | |
| §146.85(b)(1)(i) | | The Director receives and approves the completed post-injection site care and site closure plan; and | | | | 9.1 |
| §146.85(b)(1)(ii) | | The Director approves site closure. | | | | 9.1 |
| §146.85(c) | | The owner or operator must have a detailed written estimate, in current dollars, of the cost of performing corrective action on wells in the area of review, plugging the injection well(s), post-injection site care and site closure, and emergency and remedial response. | | | | 9.2,9.3, 9.4, 9.5,9.6 |

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| §146.85(c)(1) | | The cost estimate must be performed for each phase separately and must be based on the costs to the regulatory agency of hiring a third party to perform the required activities. A third party is a party who is not within the corporate structure of the owner or operator. | | | | |
| §146.85(c)(2) | | During the active life of the geologic sequestration project, the owner or operator must adjust the cost estimate for inflation within 60 days prior to the anniversary date of the establishment of the financial instrument(s) used to comply with paragraph (a) of this section and provide this adjustment to the Director. The owner or operator must also provide to the Director written updates of adjustments to the cost estimate within 60 days of any amendments to the area of review and corrective action plan (§ 146.84), the injection well plugging plan (§ 146.92), the post-injection site care and site closure plan (§ 146.93), and the emergency and remedial response plan (§ 146.94). | | | | 9.8 |
| §146.85(c)(3) | | The Director must approve any decrease or increase to the initial cost estimate. During the active life of the geologic sequestration project, the owner or operator must revise the cost estimate no later than 60 days after the Director has approved the request to modify the area of review and corrective action plan (§ 146.84), the injection well plugging plan (§ 146.92), the post-injection site care and site closure plan (§ 146.93), and the emergency and response plan (§ 146.94), if the change in the plan increases the cost. If the change to the plans decreases the cost, any withdrawal of funds must be approved by the Director. Any decrease to the value of the financial assurance instrument must first be approved by the Director. The revised cost estimate must be adjusted for inflation as specified at paragraph (c)(2) of this section. | | | | |
| §146.85(c)(4) | | Whenever the current cost estimate increases to an amount greater than the face amount of a financial instrument currently in use, the owner or operator, within 60 days after the increase, must either cause the face amount to be increased to an amount at least equal to the current cost estimate and submit evidence of such increase to the Director, or obtain other financial responsibility instruments to cover the increase. Whenever the current cost estimate decreases, the face amount of the financial assurance instrument may be reduced to the amount of the current cost estimate only after the owner or operator has received written approval from the Director. | | | | 9.8 |
| §146.85(c)(d) | | The owner or operator must notify the Director by certified mail of adverse financial conditions such as bankruptcy that may affect the ability to carry out injection well plugging and post-injection site care and site closure. | | | | 9.2 |
| §146.85(c)(d)(1) | | In the event that the owner or operator or the third party provider of a financial responsibility instrument is going through a bankruptcy, the owner or operator must notify the Director by certified mail of the commencement of a voluntary or involuntary proceeding under Title 11 (Bankruptcy), U.S. Code, naming the owner or operator as debtor, within 10 days after commencement of the proceeding. | | | | |
| §146.85(c)(d)(2) | | A guarantor of a corporate guarantee must make such a notification to the Director if he/she is named as debtor, as required under the terms of the corporate guarantee. | | | | |

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| §146.85(c)(d)(3) | | An owner or operator who fulfills the requirements of paragraph (a) of this section by obtaining a trust fund, surety bond, letter of credit, escrow account, or insurance policy will be deemed to be without the required financial assurance in the event of bankruptcy of the trustee or issuing institution, or a suspension or revocation of the authority of the trustee institution to act as trustee of the institution issuing the trust fund, surety bond, letter of credit, escrow account, or insurance policy. The owner or operator must establish other financial assurance within 60 days after such an event. | | | | |
| §146.85(e) | Financial Responsibility | The owner or operator must provide an adjustment of the cost estimate to the Director within 60 days of notification by the Director, if the Director determines during the annual evaluation of the qualifying financial responsibility instrument(s) that the most recent demonstration is no longer adequate to cover the cost of corrective action (as required by § 146.84), injection well plugging (as required by § 146.92), post-injection site care and site closure (as required by § 146.93), and emergency and remedial response (as required by § 146.94). | | | | |
| §146.85(f) | Financial Responsibility | The Director must approve the use and length of pay-in-periods for trust funds or escrow accounts. | | | | |
| §146.86 | Injection well construction requirements | | §5.203 (e)(2) | Injection well construction | Construction information. The applicant must provide the following information for each well to allow the director to determine whether the proposed well construction and completion design will meet the general performance criteria in paragraph (1) of this subsection: | |
| §146.86(a) | Injection well construction requirements | General. The owner or operator must ensure that all Class VI wells are constructed and completed to: | §5.203 (e)(1)(A) | Injection well construction | General. The operator of a geologic storage facility must ensure that all anthropogenic CO2 injection wells are constructed and completed in a manner that will: | |
| §146.86(a) | Injection well construction requirements | General. The owner or operator must ensure that all Class VI wells are constructed and completed to: | §5.203 (f)(1) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | Logs and surveys of newly drilled and completed injection wells. | 4.2.4.2 |
| §146.86(a)(1) | Injection well construction requirements | Prevent the movement of fluids into or between USDWs or into any unauthorized zones; | §5.203 (e)(1)(A)(i) | Injection well construction | Prevent the movement of injected CO2 or displaced fromation fluids into any unauthorized zones or into any areas where they could endanger USDWs; | 4.2.3.2, 4.2.3.3 |
| §146.86(a)(2) | Injection well construction requirements | Permit the use of appropriate testing devices and workover tools; and | §5.203 (e)(1)(A)(ii) | Injection well construction | Allow the use of appropriate testing devices and workover tools; and | 4.2.3.4 |
| §146.86(a)(3) | Injection well construction requirements | Permit continuous monitoring of the annulus space between the injection tubing and long string casing. | §5.203 (e)(1)(A)(iii) | Injection well construction | Allow continuous monitoring of the annulus space between the injection tubing and long string casing. | 4.2.1 |
| §146.86(b) | Injection well construction requirements | Casing and cementing of Class VI wells. | §5.203 (e)(1)(B) | Injection well construction | Casing and Cementing of anthropogenic CO2 injection wells | |
| §146.86(b) | Injection well construction requirements | Casing and cement or other materials used in the construction of each Class VI well must have sufficient structural strength and be designed for the life of the geologic sequestration project. All well materials must be compatible with fluids with which the materials may be expected to come into contact and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the Director. The casing and cementing program must be designed to prevent the movement of fluids into or between USDWs. In order to allow the Director to determine and specify casing and cementing requirements, the owner or operator must provide the following information: | §5.203 (e)(1)(B)(ii) | Injection well construction | Casing and cement, cement additives, and/or other materials used in the construction of each injection well must have sufficient structural strength and must be of sufficient quality and quantity to maintain integrity over the design life of the injection well. All well materials must be suitable for use with fluids with which the well materials may be expected to come into contact and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards approved by the Director. | 4.2.1 |
| §146.86(b)(1)(i) | Injection well construction requirements | Depth to the injection zone(s); | §5.203 (e)(2)(A) | Injection well construction | Depth to the injection zone(s); | 4.2.1 |

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| §146.86(b)(1)(ii) | Injection well construction requirements | Injection pressure, external pressure, internal pressure, and axial loading; | | | | 4.2.3, 4.2.3.6 |
| §146.86(b)(1)(iii) | Injection well construction requirements | Hole size; | §5.203 (e)(2)(B) | Injection well construction | Hole size | 4.2.3 |
| §146.86(b)(1)(iv) | Injection well construction requirements | Size and grade of all casing strings (wall thickness, external diameter, nominal weight, length, joint specification, and construction material); | §5.203 (e)(2)(C) | Injection well construction | size and grade of all casing and tubing strings (e.g., wall thickness, external diameter, nominal weight, length, joint specification and construction material, tubing tensile, burst, and collapse strengths); | 4.2.3.2, 4.2.3.3, 4.2.3.4 |
| §146.86(b)(1)(ix) | Injection well construction requirements | Quantity, chemical composition, and temperature of the carbon dioxide stream. | §5.203 (e)(2)(J) | Injection well construction | Quantity, chemical composition, and temperature of the carbon dioxide stream. | 4.2.3 |
| §146.86(b)(1)(v) | Injection well construction requirements | Corrosiveness of the carbon dioxide stream and formation fluids; | §5.203 (e)(2)(F) | Injection well construction | a description of the capability of the materials to withstand corrosion when exposed to a combination of the CO2 stream and formation fluids; | Appendix D |
| §146.86(b)(1)(vi) | Injection well construction requirements | Down-hole temperatures; | §5.203 (e)(2)(G) | Injection well construction | Down-hole temperatures and pressures | 4.2.3 |
| §146.86(b)(1)(vii) | Injection well construction requirements | Lithology of injection and confining zone(s); | §5.203 (e)(2)(H) | Injection well construction | Lithology of injection and confining zone(s) | 1.2.4 |
| §146.86(b)(1)(viii) | Injection well construction requirements | Type or grade of cement and cement additives; and | §5.203 (e)(2)(I) | Injection well construction | Type or grade of cement and cement additives; and | 4.2.3.3, Appendix C |
| §146.86(b)(2) | Injection well construction requirements | Surface casing must extend through the base of the lowermost USDW and be cemented to the surface through the use of a single or multiple strings of casing and cement. | §5.203 (e)(1)(B)(iii) | Injection well construction | Surface casing must extend through the base of the lowermost USDW above the injection zone and be cemented to the surface | 4.2.2 |
| §146.86(b)(3) | Injection well construction requirements | At least one long string casing, using a sufficient number of centralizers, must extend to the injection zone and must be cemented by circulating cement to the surface in one or more stages. | §5.203 (e)(1)(B)(v) | Injection well construction | At least one long string casing, using a sufficient number of centralizers, must extend to the injection zone and must be cemented by circulating cement to the surface in one or more stages. The long string casing must isolate the injection zone and other intervals as necessary for the protection of USDWs and to ensure confinement of the injected and formation fluids to the permitted injection zone using cement and/or other isolation techniques. If the long string casing does not extend through the injection zone, another well string or liner must be cemented through the injection zone (for example, a chrome liner). | 4.2.3.5 |
| §146.86(b)(4) | Injection well construction requirements | Circulation of cement may be accomplished by staging. The Director may approve an alternative method of cementing in cases where the cement cannot be recirculated to the surface, provided the owner or operator can demonstrate by using logs that the cement does not allow fluid movement behind the well bore. | §5.203 (e)(1)(B)(iv) | Injection well construction | Circulation of cement may be accomplished by staging. The Director may approve an alternative method of cementing in cases where the cement cannot be recirculated to the surface, provided the owner or operator can demonstrate by using logs that the cement does not allow fluid movement behind the well bore. | |
| §146.86(b)(5) | Injection well construction requirements | Cement and cement additives must be compatible with the carbon dioxide stream and formation fluids and of sufficient quality and quantity to maintain integrity over the design life of the geologic sequestration project. The integrity and location of the cement shall be verified using technology capable of evaluating cement quality radially and identifying the location of channels to ensure that USDWs are not endangered. | §5.203 (e)(1)(B)(vi) | Injection well construction | The applicant must verify the integrity and location of the cement using technology capable of radial evaluation of cement quality and identification of the location of channels to ensure that USDWs will not be endangered. | 4.2.4.2 |
| §146.86(c)(1) | Injection well construction requirements | Tubing and packer materials used in the construction of each Class VI well must be compatible with fluids with which the materials may be expected to come into contact and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the Director. | | | | 4.2.1, Appendix D |
| §146.86(c)(2) | Injection well construction requirements | All owners or operators of Class VI wells must inject fluids through tubing with a packer set at a depth opposite a cemented interval at the location approved by the Director. | §5.203 (e)(1)(C)(i) | Injection well construction | All injection wells must inject fluids through tubing set on a mechanical packer. Packers must be set no higher than 100 feet above the top of the permitted injection interval or at a location approved by the director. | 4.2.1 |
| §146.86(c)(3) | Injection well construction requirements | In order for the Director to determine and specify requirements for tubing and packer, the owner or operator must submit the following information: | | | | |
| §146.86(c)(3)(i) | Injection well construction requirements | Depth of setting; | | | | 4.2.1 |

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| §146.86(c)(3)(ii) | Injection well construction requirements | Characteristics of the carbon dioxide stream (chemical content, corrosiveness, temperature, and density) and formation fluids; | | | | 4.2.3 |
| §146.86(c)(3)(iii) | Injection well construction requirements | Maximum proposed injection pressure; | | | | 4.2.6 |
| §146.86(c)(3)(iv) | Injection well construction requirements | Maximum proposed annular pressure; | | | | 4.2.6 |
| §146.86(c)(3)(v) | Injection well construction requirements | Proposed injection rate (intermittent or continuous) and volume and/or mass of the carbon dioxide stream; | §5.203 (e)(2)(D) | Injection well construction | proposed injection rate (intermittent or continuous), maximum proposed surface injection pressure, and maximum proposed volume and/or mass of the CO2 stream to be injected; | 4,2,6 |
| §146.86(c)(3)(vi) | Injection well construction requirements | Size of tubing and casing; and | | | | 4.2.3.4, 4.2.3.6 |
| §146.86(c)(3)(vii) | Injection well construction requirements | Tubing tensile, burst, and collapse strengths. | | | | 4.2.3.6 |
| §146.87(a) | Logging, sampling, and testing prior to injection well operation | During the drilling and construction of a Class VI injection well, the owner or operator must run appropriate logs, surveys and tests to determine or verify the depth, thickness, porosity, permeability, and lithology of, and the salinity of any formation fluids in all relevant geologic formations to ensure conformance with the injection well construction requirements under § 146.86 and to establish accurate baseline data against which future measurements may be compared. The owner or operator must submit to the Director a descriptive report prepared by a knowledgeable log analyst that includes an interpretation of the results of such logs and tests. At a minimum, such logs and tests must include: | §5.203 (c)(1) | Geologic, geochemical, and hydrologic information | The applicant must submit a descriptive report prepared by a knowledgeable person that includes an interpretation of the results of appropriate logs, surveys, sampling, and testing sufficient to determine the depth, thickness, porosity, permeability, and lithology of, and the geochemistry of any formation fluids in, all relevant geologic formations. | 4.2.4.1, 4.2.4.2, 4.2.4.3, 5.4.9 |
| §146.87(a) | Logging, sampling, and testing prior to injection well operation | During the drilling and construction of a Class VI injection well, the owner or operator must run appropriate logs, surveys and tests to determine or verify the depth, thickness, porosity, permeability, and lithology of, and the salinity of any formation fluids in all relevant geologic formations to ensure conformance with the injection well construction requirements under § 146.86 and to establish accurate baseline data against which future measurements may be compared. The owner or operator must submit to the Director a descriptive report prepared by a knowledgeable log analyst that includes an interpretation of the results of such logs and tests. At a minimum, such logs and tests must include: | §5.203 (f) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | The applicant must submit a plan for logging, sampling, and testing of each injection well after permitting but prior to injection well operation. The plan need not include identical logging, sampling, and testing procedures for all wells provided there is a reasonable basis for different procedures. Such plan is not necessary for existing wells being converted to anthropogenic CO2 injection wells in accordance with this subchapter, to the extent such activities already have taken place. The plan must describe the logs, surveys, and tests to be conducted to verify the depth, thickness, porosity, permeability, and lithology of, and the salinity of any formation fluids in, the formations that are to be used for monitoring, storage, and confinement to assure conformance with the injection well construction requirements set forth in subsection (e) of this section, and to establish accurate baseline data against which future measurements may be compared. The plan must meet the following criteria and must include the following information. | 4.2.4.1, 4.2.4.2, 4.2.4.3, 5.4.9 |
| §146.87(a)(1) | Logging, sampling, and testing prior to injection well operation | Deviation checks during drilling on all holes constructed by drilling a pilot hole which is enlarged by reaming or another method. Such checks must be at sufficiently frequent intervals to determine the location of the borehole and to ensure that vertical avenues for fluid movement in the form of diverging holes are not created during drilling; and | §5.203 (f)(1)(A) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | During the drilling of any hole that is constructed by drilling a pilot hole which is enlarged by reaming or another method, the operator must perform deviation checks at sufficiently frequent intervals to determine the location of the borehole and to ensure that vertical avenues for fluid movement in the form of diverging holes are not created during drilling. | |
| §146.87(a)(2) | Logging, sampling, and testing prior to injection well operation | Before and upon installation of the surface casing: | | | | |
| §146.87(a)(2)(i) | Logging, sampling, and testing prior to injection well operation | Resistivity, spontaneous potential, and caliper logs before the casing is installed; and | §5.203 (f)(1)(B) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | Before surface casing is installed, the operator must run appropriate logs, such as resistivity, spontaneous potential, and caliper logs. | 4.2.4.2 |
| §146.87(a)(2)(ii) | Logging, sampling, and testing prior to injection well operation | A cement bond and variable density log to evaluate cement quality radially, and a temperature log after the casing is set and cemented. | | | | 4.2.4.2 |

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| | | | §5.203 (f)(1)(C) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | After each casing string is set and cemented, the operator must run logs, such as a cement bond log, variable density log, and a temperature log, to ensure proper cementing. | 4.2.4.2 |
| §146.87(a)(3) | Logging, sampling, and testing prior to injection well operation | Before and upon installation of the long string casing: | §5.203 (f)(1)(D) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | Before long string casing is installed, the operator must run logs appropriate to the geology, such as resistivity, spontaneous potential, porosity, caliper, gamma ray, and fracture finder logs, to gather data necessary to verify the characterization of the geology and hydrology. | 4.2.4.2 |
| §146.87(a)(3)(i) | Logging, sampling, and testing prior to injection well operation | Resistivity, spontaneous potential, porosity, caliper, gamma ray, fracture finder logs, and any other logs the Director requires for the given geology before the casing is installed; and | §5.203 (f)(1)(D) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | Before long string casing is installed, the operator must run logs appropriate to the geology, such as resistivity, spontaneous potential, porosity, caliper, gamma ray, and fracture finder logs, to gather data necessary to verify the characterization of the geology and hydrology. | 4.2.4.2 |
| §146.87(a)(3)(ii) | Logging, sampling, and testing prior to injection well operation | A cement bond and variable density log, and a temperature log after the casing is set and cemented. | §5.203 (f)(1)(C) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | After each casing string is set and cemented, the operator must run logs, such as a cement bond log, variable density log, and a temperature log, to ensure proper cementing. | 4.2.4.2 |
| §146.87(a)(4) | Logging, sampling, and testing prior to injection well operation | A series of tests designed to demonstrate the internal and external mechanical integrity of injection wells, which may include: | §5.203 (h)(2) | Mechanical integrity testing | Mechanical integrity testing plan. The applicant must prepare and submit a mechanical integrity testing plan as part of a permit application. [The plan must include a schedule for the performance of a series of tests at a minimum frequency of five years.] The performance tests must be designed to demonstrate the internal and external mechanical integrity of each injection well. These tests may include: | |
| §146.87(a)(4)(i) | Logging, sampling, and testing prior to injection well operation | A pressure test with liquid or gas; | §5.203 (h)(2)(A) | Mechanical integrity testing | A pressure test with liquid or gas; | 5.4.4 |
| §146.87(a)(4)(ii) | Logging, sampling, and testing prior to injection well operation | A tracer survey such as oxygen-activation logging; | §5.203 (h)(2)(B) | Mechanical integrity testing | A tracer survey such as oxygen-activation logging; | |
| §146.87(a)(4)(iii) | Logging, sampling, and testing prior to injection well operation | A temperature or noise log; | §5.203 (h)(2)(C) | Mechanical integrity testing | A temperature or noise log; | 5.4.5 |
| §146.87(a)(4)(iv) | Logging, sampling, and testing prior to injection well operation | A casing inspection log; and | §5.203 (h)(2)(D) | Mechanical integrity testing | A casing inspection log; and | 5.4.8 |
| §146.87(a)(5) | Logging, sampling, and testing prior to injection well operation | Any alternative methods that provide equivalent or better information and that are required by and/or approved of by the Director. | §5.203 (h)(2)(E) | Mechanical integrity testing | Any alternative methods approved by the director, and if necessary by the Administrator of EPA under 40 CFR §146.89(e), that provides equivalent or better information approved by the director. | |
| §146.87(b) | Logging, sampling, and testing prior to injection well operation | The owner or operator must take whole cores or sidewall cores of the injection zone and confining system and formation fluid samples from the injection zone(s), and must submit to the Director a detailed report prepared by a log analyst that includes: Well log analyses (including well logs), core analyses, and formation fluid sample information. The Director may accept information on cores from nearby wells if the owner or operator can demonstrate that core retrieval is not possible and that such cores are representative of conditions at the well. The Director may require the owner or operator to core other formations in the borehole. | §5.203 (f)(3)(B) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | The operator must submit analyses of whole cores or sidewall cores representative of the injection zone and confining zone and formation fluid samples from nearby wells or other data if the operator can demonstrate to the director that such data are representative of conditions at the proposed injection well. | 4.2.4.1 |
| §146.87(c) | Logging, sampling, and testing prior to injection well operation | The owner or operator must record the fluid temperature, pH, conductivity, reservoir pressure, and static fluid level of the injection zone(s). | §5.203 (f)(3)(A) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | The operator must record the formation fluid temperature, pH, conductivity, reservoir pressure, and static fluid level of the injection zone. | 4.2.4.3 |
| §146.87(d) | Logging, sampling, and testing prior to injection well operation | At a minimum, the owner or operator must determine or calculate the following information concerning the injection and confining zone(s): | §5.203 (f)(2) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | Testing and determination of hydrogeologic characteristics of injection and confining zone. | |
| §146.87(d)(1) | Logging, sampling, and testing prior to injection well operation | Fracture pressure; | | | | 1.5.3, 4.2.4.4 |
| §146.87(d)(2) | Logging, sampling, and testing prior to injection well operation | Other physical and chemical characteristics of the injection and confining zone(s); and | | | | 1.2.4, 4.2.4.2 |

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| §146.87(d)(3) | Logging, sampling, and testing prior to injection well operation | Physical and chemical characteristics of the formation fluids in the injection zone(s). | | | | 1.6.1, 4.2.4.3 |
| §146.87(e) | Logging, sampling, and testing prior to injection well operation | Upon completion, but prior to operation, the owner or operator must conduct the following tests to verify hydrogeologic characteristics of the injection zone(s): | | | | |
| §146.87(e)(1) | Logging, sampling, and testing prior to injection well operation | A pressure fall-off test; and, | §5.203 (f)(2)(B) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | The operator must perform an initial pressure fall-off or other test and submit to the director a written report of the results of the test, including details of the methods used to perform the test and to interpret the results, all necessary graphs, and the testing log, to verify permeability, injectivity, and initial pressure using water or CO2. | 5.4.2, 5.4.6 |
| §146.87(e)(2) | | A pump test; or | | | | |
| §146.87(e)(3) | | Injectivity tests. | | | | 5.4.2 |
| §146.87(f) | Logging, sampling, and testing prior to injection well operations | The owner or operator must provide the Director with the opportunity to witness all logging and testing by this subpart. The owner or operator must submit a schedule of such activities to the Director 30 days prior to conducting the first test and submit any changes to the schedule 30 days prior to the next scheduled test. | §5.206 (i) | Permit Standards | Commission witnessing of testing and logging. The operator must provide the division with the opportunity to witness all planned well workovers, stimulation activities, other than stimulation for formation testing, and testing and logging. The operator must submit a proposed schedule of such activities to the Commission at least 30 days prior to conducting the first such activity and submit notice at least 48 hours in advance of any actual activity. Such activities shall not commence before the end of the 30 days unless authorized by the director. | 4.2.4.2, 4.3.2, 5.4.8 |
| §146.88(a) | Injection well operating requirements | Except during stimulation, the owner or operator must ensure that injection pressure does not exceed 90 percent of the fracture pressure of the injection zone(s) so as to ensure that the injection does not initiate new fractures or propagate existing fractures in the injection zone(s). In no case may injection pressure initiate fractures in the confining zone(s) or cause the movement of injection or formation fluids that endangers a USDW. Pursuant to requirements at § 146.82(a)(9), all stimulation programs must be approved by the Director as part of the permit application and incorporated into the permit. | §5.203 (i)(2)(C) | Operating Information | in no case may cause the movement of injection fluids or formation fluids in a manner that endangers USDWs. | 4.2.5, 4.2.6 |
| §146.88(a) | | Except during stimulation, the owner or operator must ensure that injection pressure does not exceed 90 percent of the fracture pressure of the injection zone(s) so as to ensure that the injection does not initiate new fractures or propagate existing fractures in the injection zone(s). In no case may injection pressure initiate fractures in the confining zone(s) or cause the movement of injection or formation fluids that endangers a USDW. Pursuant to requirements at § 146.82(a)(9), all stimulation programs must be approved by the Director as part of the permit application and incorporated into the permit. | | | | |
| §146.88(b) | Injection well construction requirements | Injection between the outermost casing protecting USDWs and the well bore is prohibited. | §5.206 (d)(2)(A) | Operating a geologic storage facility | Injection between the outermost casing protecting USDWs and the well bore is prohibited. | |
| §146.88(c) | Injection well construction requirements | The owner or operator must fill the annulus between the tubing and the long string casing with a non-corrosive fluid approved by the Director. The owner or operator must maintain on the annulus a pressure that exceeds the operating injection pressure, unless the Director determines that such requirement might harm the integrity of the well or endanger USDWs. | §5.206 (d)(2)(D) | Operating a geologic storage facility | The owner or operator must fill the annulus between the tubing and the long string casing with a corrosion inhibiting fluid approved by the Director. The owner or operator must maintain on the annulus a pressure that exceeds the operating injection pressure, unless the Director determines that such requirement might harm the integrity of the well or endanger USDWs. | 4.2.3.7 |
| §146.88(d) | Injection well operating requirements | Other than during periods of well workover (maintenance) approved by the Director in which the sealed tubing-casing annulus is disassembled for maintenance or corrective procedures, the owner or operator must maintain mechanical integrity of the injection well at all times. | §5.203 (h)(1)(A) | Mechanical integrity testing | Other than during periods of well workover in which the sealed tubing-casing annulus is of necessity disassembled for maintenance or corrective procedures, the operator must maintain mechanical integrity of the injection well at all times. | |

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| §146.88(d) | Injection well operating requirements | Other than during periods of well workover (maintenance) approved by the Director in which the sealed tubing-casing annulus is disassembled for maintenance or corrective procedures, the owner or operator must maintain mechanical integrity of the injection well at all times. | §5.206 (f)(2) | Mechanical integrity | Other than during periods of well workover (maintenance) approved by the Director in which the sealed tubing casing annulus is disassembled for maintenance or corrective procedures, the owner or operator must maintain mechanical integrity of the injection well at all times. | |
| §146.88(e) | Injection well operating requirements | The owner or operator must install and use: | §5.206 (d)(2)(F) | Operating a geologic storage facility | The operator must comply with the following requirements for alarms and automatic shut-off systems. | |
| §146.88(e)(1) | Injection well operating requirements | Continuous recording devices to monitor: The injection pressure; the rate, volume and/or mass, and temperature of the carbon dioxide stream; and the pressure on the annulus between the tubing and the long string casing and annulus fluid volume; and | §5.206 (d)(2)(F)(i) | Operating a geologic storage facility | The operator must install and use alarms and automatic shut-off systems designed to alert the operator and shut-in the well when operating parameters such as annulus pressure, injection rate or other parameters diverge from permitted ranges and/or gradients. On offshore wells, the automatic shut-off systems must be installed down-hole. | 5.5.1 |
| §146.88(e)(2) | Injection well operating requirements | Alarms and automatic surface shut-off systems or, at the discretion of the Director, down-hole shut-off systems (e.g., automatic shut-off, check valves) for onshore wells or, other mechanical devices that provide equivalent protection; and | §5.206 (d)(2)(F)(i) | Operating a geologic storage facility | The operator must install and use alarms and automatic shut-off systems designed to alert the operator and shut-in the well when operating parameters such as annulus pressure, injection rate or other parameters diverge from permitted ranges and/or gradients. On offshore wells, the automatic shut-off systems must be installed down-hole. | 5.4.7 |
| §146.88(e)(3) | Injection well operating requirements | Alarms and automatic down-hole shut-off systems for wells located offshore but within State territorial waters, designed to alert the operator and shut-in the well when operating parameters such as annulus pressure, injection rate, or other parameters diverge beyond permitted ranges and/or gradients specified in the permit. | §5.206 (d)(2)(F)(i) | Operating a geologic storage facility | The operator must install and use alarms and automatic shut-off systems designed to alert the operator and shut-in the well when operating parameters such as annulus pressure, injection rate or other parameters diverge from permitted ranges and/or gradients. On offshore wells, the automatic shut-off systems must be installed down-hole. | |
| §146.88(f) | Injection well operating requirements | If a shutdown (i.e., down-hole or at the surface) is triggered or a loss of mechanical integrity is discovered, the owner or operator must immediately investigate and identify as expeditiously as possible the cause of the shutoff. If, upon such investigation, the well appears to be lacking mechanical integrity, or if monitoring required under paragraph (e) of this section otherwise indicates that the well may be lacking mechanical integrity, the owner or operator must: | §5.206 (d)(2)(F)(ii) | Operating a geologic storage facility | If a shutdown (i.e., down-hole or at the surface) is triggered or a loss of mechanical integrity is discovered, the owner or operator must immediately investigate and identify as expeditiously as possible the cause. If, upon such investigation, the well appears to be lacking mechanical integrity, or if monitoring otherwise indicates that the well may be lacking mechanical integrity, the owner or operator must | 8.4.8 |
| §146.88(f)(1) | Injection well operating requirements | Immediately cease injection; | §5.206 (d)(2)(F)(ii)(I) | Operating a geologic storage facility | Immediately cease injection; | 8.4.8 |
| §146.88(f)(2) | Injection well operating requirements | Take all steps reasonably necessary to determine whether there may have been a release of the injected carbon dioxide stream or formation fluids into any unauthorized zone; | §5.206 (d)(2)(F)(ii)(II) | Operating a geologic storage facility | Take all steps reasonably necessary to determine whether there may have been a release of the injected carbon dioxide stream or formation fluids into any unauthorized zone | 8.4.8 |
| §146.88(f)(3) | Injection well operating requirements | Notify the Director within 24 hours; | §5.206 (d)(2)(F)(ii)(III) | Operating a geologic storage facility | Notify the Director within 24 hours | 8.4.8 |
| §146.88(f)(4) | Injection well operating requirements | Restore and demonstrate mechanical integrity to the satisfaction of the Director prior to resuming injection; and | §5.206 (d)(2)(F)(ii)(IV) | Operating a geologic storage facility | Restore and demonstrate mechanical integrity to the satisfaction of the Director prior to resuming injection; and | 8.4.8 |
| §146.88(f)(5) | Injection well operating requirements | Notify the Director when injection can be expected to resume. | §5.206 (d)(2)(F)(ii)(V) | Operating a geologic storage facility | Notify the Director when injection can be expected to resume | 8.4.8 |
| §146.89 | Mechanical Integrity | Mechanical Integrity | §5.203 (h) | Mechanical integrity testing | Mechanical integrity testing. | |
| §146.89 | Mechanical Integrity | Mechanical Integrity | §5.203 (h)(1) | Mechanical integrity testing | Criteria. This paragraph establishes the criteria for the mechanical integrity testing plan for anthropogenic CO2 injection wells that an applicant must include in an application. | 5.4.4 |
| §146.89 | Mechanical Integrity | Mechanical Integrity | §5.206 (f) | Mechanical integrity | Mechanical Integrity | |
| §146.89(a) | Mechanical Integrity | A Class VI well has mechanical integrity if: | | | | |
| §146.89(a)(1) | Mechanical Integrity | There is no significant leak in the casing, tubing, or packer; and | | | | |
| §146.89(a)(2) | Mechanical Integrity | There is no significant fluid movement into a USDW through channels adjacent to the injection well bore. | | | | |

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| §146.89(b) | Mechanical Integrity | To evaluate the absence of significant leaks under paragraph (a)(1) of this section, owners or operators must, following an initial annulus pressure test, continuously monitor injection pressure, rate, injected volumes; pressure on the annulus between tubing and long-string casing; and annulus fluid volume as specified in § 146.88 (e); | §5.203 (h)(1)(C) | Mechanical integrity testing | Following an initial annulus pressure test, the operator must continuously monitor injection pressure, rate, injected volumes and pressure on the annulus between tubing and long-string casing to confrim that the injected fluids are confined to the injection zone. | 5.5.1 |
| §146.89(c) | Mechanical Integrity | At least once per year, the owner or operator must use one of the following methods to determine the absence of significant fluid movement under paragraph (a)(2) of this section: | §5.203 (h)(1)(D) | Mechanical integrity testing | At least once per year until the injection well is plugged the operator must confirm the absence of significant fluid movement into a USDW through channels adjacent to the injection wellbore (external integrity) using a method approved by the director (e.g., diagnostic surveys such as oxygen-activation logging or temperature or noise logs). | |
| §146.89(c)(1) | Mechanical Integrity | An approved tracer survey such as an oxygen-activation log; or | §5.203 (h)(1)(D) | Mechanical integrity testing | At least once per year until the injection well is plugged the operator must confirm the absence of significant fluid movement into a USDW through channels adjacent to the injection wellbore (external integrity) using a method approved by the director (e.g., diagnostic surveys such as oxygen-activation logging or temperature or noise logs). | |
| §146.89(c)(2) | Mechanical Integrity | A temperature or noise log. | §5.203 (h)(1)(D) | Mechanical integrity testing | At least once per year until the injection well is plugged the operator must confirm the absence of significant fluid movement into a USDW through channels adjacent to the injection wellbore (external integrity) using a method approved by the director (e.g., diagnostic surveys such as oxygen-activation logging or temperature or noise logs). | 5.4.5 |
| §146.89(d) | Mechanical Integrity | If required by the Director, at a frequency specified in the testing and monitoring plan required at § 146.90, the owner or operator must run a casing inspection log to determine the presence or absence of corrosion in the long-string casing. | | | | |
| §146.89(e) | Mechanical Integrity | The Director may require any other test to evaluate mechanical integrity under paragraphs (a)(1) or (a)(2) of this section. Also, the Director may allow the use of a test to demonstrate mechanical integrity other than those listed above with the written approval of the Administrator. To obtain approval for a new mechanical integrity test, the Director must submit a written request to the Administrator setting forth the proposed test and all technical data supporting its use. The Administrator may approve the request if he or she determines that it will reliably demonstrate the mechanical integrity of wells for which its use is proposed. Any alternate method approved by the Administrator will be published in the Federal Register and may be used in all States in accordance with applicable State law unless its use is restricted at the time of approval by the Administrator. | | | | |
| §146.89(f) | Mechanical Integrity | In conducting and evaluating the tests enumerated in this section or others to be allowed by the Director, the owner or operator and the Director must apply methods and standards generally accepted in the industry. When the owner or operator reports the results of mechanical integrity tests to the Director, he/she shall include a description of the test(s) and the method(s) used. In making his/her evaluation, the Director must review monitoring and other test data submitted since the previous evaluation. | | | | |
| §146.89(g) | Mechanical Integrity | The Director may require additional or alternative tests if the results presented by the owner or operator under paragraphs (a) through (d) of this section are not satisfactory to the Director to demonstrate that there is no significant leak in the casing, tubing, or packer, or to demonstrate that there is no significant movement of fluid into a USDW resulting from the injection activity as stated in paragraphs (a)(1) and (2) of this section. | §5.206 (f)(4) | Mechanical integrity | The director may require additional or alternative tests if the results presented by the operator do not demonstrate to the director that there is no significant leak in the casing, tubing, or packer or movement of fluid into or between formations containing USDWs resulting from the injection activity. | |

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| §146.90 | Testing and monitoring requirements | The owner or operator of a Class VI well must prepare, maintain, and comply with a testing and monitoring plan to verify that the geologic sequestration project is operating as permitted and is not endangering USDWs. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The testing and monitoring plan must be submitted with the permit application, for Director approval, and must include a description of how the owner or operator will meet the requirements of this section, including accessing sites for all necessary monitoring and testing during the life of the project. Testing and monitoring associated with geologic sequestration projects must, at a minimum, include: | §5.203 (j) | Plan for monitoring, sampling, and testing after initiation of operation | Plan for monitoring, sampling, and testing after initiation of operation. | 5.2 |
| §146.90 | Testing and monitoring requirements | The owner or operator of a Class VI well must prepare, maintain, and comply with a testing and monitoring plan to verify that the geologic sequestration project is operating as permitted and is not endangering USDWs. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The testing and monitoring plan must be submitted with the permit application, for Director approval, and must include a description of how the owner or operator will meet the requirements of this section, including accessing sites for all necessary monitoring and testing during the life of the project. Testing and monitoring associated with geologic sequestration projects must, at a minimum, include: | §5.203 (j)(1) | Plan for monitoring, sampling, and testing after initiation of operation | The applicant must submit a monitoring, sampling, and testing plan for verifying that the geologic storage facility is operating as permitted and that the injected fluids are confined to the injection zone. | 5.2 |
| §146.90 | Testing and monitoring requirements | The owner or operator of a Class VI well must prepare, maintain, and comply with a testing and monitoring plan to verify that the geologic sequestration project is operating as permitted and is not endangering USDWs. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The testing and monitoring plan must be submitted with the permit application, for Director approval, and must include a description of how the owner or operator will meet the requirements of this section, including accessing sites for all necessary monitoring and testing during the life of the project. Testing and monitoring associated with geologic sequestration projects must, at a minimum, include: | §5.203 (j)(2) | Plan for monitoring, sampling, and testing after initiation of operation | The plan must include the following: | |
| §146.90(a) | Testing and monitoring requirements | Analysis of the carbon dioxide stream with sufficient frequency to yield data representative of its chemical and physical characteristics; | §5.203 (j)(2)(A) | Plan for monitoring, sampling, and testing after initiation of operation | The analysis of the carbon dioxide stream prior to injection with sufficient frequency to yield data representative of its chemical and physical characteristics; | 5.4.3 |
| §146.90(b) | Testing and monitoring requirements | Installation and use, except during well workovers as defined in § 146.88(d), of continuous recording devices to monitor injection pressure, rate, and volume; the pressure on the annulus between the tubing and the long string casing; and the annulus fluid volume added; | §5.203 (j)(2)(B) | Plan for monitoring, sampling, and testing after initiation of operation | The installation and use of continuous recording devices to monitor injection pressure, rate, and volume and the pressure on the annulus between the tubing and the long string casing, except during workovers | 5.5.1 |
| §146.90(c) | Testing and monitoring requirements | Corrosion monitoring of the well materials for loss of mass, thickness, cracking, pitting, and other signs of corrosion, which must be performed on a quarterly basis to ensure that the well components meet the minimum standards for material strength and performance set forth in § 146.86(b), by: | §5.203 (j)(2)(C) | Plan for monitoring, sampling, and testing after initiation of operation | After initiation of injection, the performance on a semi-annual basis of corrosion monitoring of the well materials for loss of mass, thickness, cracking, pitting, and other signs of corrosion, which must be performed on a quarterly basis to ensure that the well components meet the minimum standards for material strength and performance set forth in subsection (e)(1)(A) of this section. The operator must report the results of such monitoring annually. Corrosion monitoring may be accomplished by: | 5.5.2 |

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| §146.90(c)(1) | Testing and monitoring requirements | Analyzing coupons of the well construction materials placed in contact with the carbon dioxide stream; or | §5.203 (j)(2)(C)(i) | Plan for monitoring, sampling, and testing after initiation of operation | Analyzing coupons of the well construction materials placed in contact with the carbon dioxide stream; or | 5.5.2.1 |
| §146.90(c)(2) | Testing and monitoring requirements | Routing the carbon dioxide stream through a loop constructed with the material used in the well and inspecting the materials in the loop; or | §5.203 (j)(2)(C)(ii) | Plan for monitoring, sampling, and testing after initiation of operation | Routing the carbon dioxide stream through a loop constructed with the material used in the well and inspecting the materials in the loop; or | |
| §146.90(c)(3) | Testing and monitoring requirements | Using an alternative method approved by the Director; | §5.203 (j)(2)(C)(iii) | Plan for monitoring, sampling, and testing after initiation of operation | using an alternative method, materials, or time period approved by the director; | |
| §146.90(d) | Testing and monitoring requirements | Periodic monitoring of the ground water quality and geochemical changes above the confining zone(s) that may be a result of carbon dioxide movement through the confining zone(s) or additional identified zones including: | §5.203 (j)(2)(D) | Plan for monitoring, sampling, and testing after initiation of operation | Monitoring of geochemical and geophysical changes, including: | |
| §146.90(d) | Testing and monitoring requirements | Periodic monitoring of the ground water quality and geochemical changes above the confining zone(s) that may be a result of carbon dioxide movement through the confining zone(s) or additional identified zones including: | §5.203 (j)(2)(D)(ii) | Plan for monitoring, sampling, and testing after initiation of operation | Periodic monitoring of the quality and geochemistry of a USDW within the AOR and the formation fluid in a permeable and porous formation near to and above the top confining zone to detect any movement of the injected CO2 through the confining zone into that monitored formation; | 4.3.4 |
| §146.90(d)(1) | Testing and monitoring requirements | The location and number of monitoring wells based on specific information about the geologic sequestration project, including injection rate and volume, geology, the presence of artificial penetrations, and other factors; and | §5.203 (j)(2)(D)(iii) | Plan for monitoring, sampling, and testing after initiation of operation | The location and number of monitoring wells justified on the basis of AOR, injection rate and volume, geology, the presence of artificial penetrations and other factors specific to the geologic storage facility; and | 5.5.4 |
| §146.90(d)(2) | Testing and monitoring requirements | The monitoring frequency and spatial distribution of monitoring wells based on baseline geochemical data that has been collected under § 146.82(a)(6) and on any modeling results in the area of review evaluation required by § 146.84(c). | §5.203 (j)(2)(D)(iv) | Plan for monitoring, sampling, and testing after initiation of operation | The monitoring frequency and spatial distribution of monitoring wells based on baseline geochemical data that has been collected under subsection (c)(2) of this section and any modeling results in the AOR evaluation; | 5.5.4 |
| §146.90(e) | | A demonstration of external mechanical integrity pursuant to § 146.89(c) at least once per year until the injection well is plugged; and, if required by the Director, a casing inspection log pursuant to requirements at § 146.89(d) at a frequency established in the testing and monitoring plan; | | | | 5.4.5 |
| §146.90(f) | Testing and monitoring requirements | A pressure fall-off test at least once every five years unless more frequent testing is required by the Director based on site-specific information; | §5.203 (j)(2)(F) | Plan for monitoring, sampling, and testing after initiation of operation | A pressure fall-off test at least once every five years unless more frequent testing is required by the director based on site-specific information; and | 5.4.6 |
| §146.90(g) | Testing and monitoring requirements | Testing and monitoring to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure (e.g., the pressure front) by using: | §5.203 (j)(2)(E) | Plan for monitoring, sampling, and testing after initiation of operation | tracking the extent of the CO2 plume and the position of the pressure front by using indirect, geophysical techniques, which may include seismic, electrical, gravity, or electromagnetic surveys and/or down-hole CO2 detection tools; | |
| §146.90(g)(1) | | Direct methods in the injection zone(s); and, | | | | 5.5.7.1 |
| §146.90(g)(2) | Testing and monitoring requirements | Indirect methods (e.g., seismic, electrical, gravity, or electromagnetic surveys and/or down-hole carbon dioxide detection tools), unless the Director determines, based on site-specific geology, that such methods are not appropriate; | §5.203 (j)(2)(E) | Plan for monitoring, sampling, and testing after initiation of operation | tracking the extent of the CO2 plume and the position of the pressure front by using indirect, geophysical techniques, which may include seismic, electrical, gravity, or electromagnetic surveys and/or down-hole CO2 detection tools; | 5.5.7.2 |
| §146.90(h) | | The Director may require surface air monitoring and/or soil gas monitoring to detect movement of carbon dioxide that could endanger a USDW. | | | | |
| §146.90(h)(1) | | Design of Class VI surface air and/or soil gas monitoring must be based on potential risks to USDWs within the area of review; | | | | 5.5.3 |
| §146.90(h)(2) | | The monitoring frequency and spatial distribution of surface air monitoring and/or soil gas monitoring must be decided using baseline data, and the monitoring plan must describe how the proposed monitoring will yield useful information on the area of review delineation and/or compliance with standards under § 144.12 of this chapter; | | | | 5.5.3 |

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| §146.90(h)(3) | | If an owner or operator demonstrates that monitoring employed under §§ 98.440 to 98.449 of this chapter (Clean Air Act, 42 U.S.C. 7401 et seq.) accomplishes the goals of paragraphs (h)(1) and (2) of this section, and meets the requirements pursuant to § 146.91(c)(5), a Director that requires surface air/soil gas monitoring must approve the use of monitoring employed under §§ 98.440 to 98.449 of this chapter. Compliance with §§ 98.440 to 98.449 of this chapter pursuant to this provision is considered a condition of the Class VI permit; | | | | |
| §146.90(i) | Testing and monitoring requirements | Any additional monitoring, as required by the Director, necessary to support, upgrade, and improve computational modeling of the area of review evaluation required under § 146.84(c) and to determine compliance with standards under § 144.12 of this chapter; | §5.203 (j)(2)(G) | Plan for monitoring, sampling, and testing after initiation of operation | Additional monitoring as the director may determine to be necessary to support, upgrade, and improve computational modeling of the AOR evaluation and to determine compliance with the requirements that the injection activity not allow the movement of fluid containing any contaminant into USDWs and that the injected fluid remain within the permitted interval. | |
| §146.90(i) | Testing and monitoring requirements | Any additional monitoring, as required by the Director, necessary to support, upgrade, and improve computational modeling of the area of review evaluation required under § 146.84(c) and to determine compliance with standards under § 144.12 of this chapter; | §5.206 (e)(3) | Monitoring, sampling, and testing requirements | The director may require additional monitoring as necessary to support, upgrade, and improve computational modeling of the AOR evaluation and to determine compliance with the requirement that the injection activity not allow movement of fluid that would endanger USDWs | |
| §146.90(j) | | The owner or operator shall periodically review the testing and monitoring plan to incorporate monitoring data collected under this subpart, operational data collected under § 146.88, and the most recent area of review reevaluation performed under § 146.84(e). In no case shall the owner or operator review the testing and monitoring plan less often than once every five years. Based on this review, the owner or operator shall submit an amended testing and monitoring plan or demonstrate to the Director that no amendment to the testing and monitoring plan is needed. Any amendments to the testing and monitoring plan must be approved by the Director, must be incorporated into the permit, and are subject to the permit modification requirements at § 144.39 or § 144.41 of this chapter, as appropriate. Amended plans or demonstrations shall be submitted to the Director as follows: | | | | 5.3 |
| §146.90(j)(1) | | Within one year of an area of review reevaluation; | | | | 5.3 |
| §146.90(j)(2) | | Following any significant changes to the facility, such as addition of monitoring wells or newly permitted injection wells within the area of review, on a schedule determined by the Director; or | | | | 5.3 |
| §146.90(j)(3) | | When required by the Director. | | | | 5.3 |
| §146.90(k) | Testing and monitoring requirements | A quality assurance and surveillance plan for all testing and monitoring requirements. | §5.203 (a)(4) | General | Reports. An applicant must ensure that all descriptive reports are prepared by a qualified and knowledgeable person and include an interpretation of the results of all logs, surveys, sampling, and tests required in this subchapter. The applicant must include in the application a quality assurance and surveillance plan for all testing and monitoring, which includes, at a minimum, validation of the analytical laboratory data, calibration of field instruments, and an explanation of the sampling and data acquisition techniques. | Section 5 |
| §146.91 | Reporting requirements | The owner or operator must, at a minimum, provide, as specified in paragraph (e) of this section, the following reports to the Director, for each permitted Class VI well: | §5.207 | Reporting and Record-Keeping | Reporting and Record-Keeping. The operator must provide, at a minimum, the following reports to the Director and retain the following information | |

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| §146.91 | Reporting requirements | The owner or operator must, at a minimum, provide, as specified in paragraph (e) of this section, the following reports to the Director, for each permitted Class VI well: | §5.207(a)(1) | Reporting and Record-Keeping | Test records. The operator must file a complete record of all tests in duplicate with the district office within 30 days after the testing. In conducting and evaluating the tests enumerated in this subchapter or others to be allowed by the director, the operator and the director must apply methods and standards generally accepted in the industry. When the operator reports the results of mechanical integrity tests to the director, the operator must include a description of any tests and methods [the test(s) and the method(s)] used. In making this evaluation, the director must review monitoring and other test data submitted since the previous evaluation. | 5.2 |
| §146.91(a) | Reporting requirements | Semi-annual reports containing: | §5.207 (a)(2)(C) | Reporting and Record-Keeping | Semi-annual reports containing: | |
| §146.91(a)(1) | Reporting requirements | Any changes to the physical, chemical, and other relevant characteristics of the carbon dioxide stream from the proposed operating data; | §5.207 (a)(2)(C)(ii) | Reporting and Record-Keeping | Any changes to the source as well as the physical, chemical, and other relevant characteristics of the carbon dioxide stream from the proposed operating data; | 5.2 |
| §146.91(a)(2) | Reporting requirements | Monthly average, maximum, and minimum values for injection pressure, flow rate and volume, and annular pressure; | §5.207 (a)(2)(C)(i) | Reporting and Record-Keeping | a summary of well head pressure monitoring; | 5.2 |
| §146.91(a)(2) | Reporting requirements | Monthly average, maximum, and minimum values for injection pressure, flow rate and volume, and annular pressure; | §5.207 (a)(2)(C)(iii) | Reporting and Record-Keeping | monthly average, maximum and minimum values for injection pressure, flow rate, temperature, and volume and/or mass, and annular pressure; | 5.2 |
| §146.91(a)(3) | Reporting requirements | A description of any event that exceeds operating parameters for annulus pressure or injection pressure specified in the permit; | §5.207 (a)(2)(C)(v) | Reporting and Record-Keeping | description of any event that significantly exceeds operating parameters for annulus pressure or injection pressure as specified in the permit; | 5.2 |
| §146.91(a)(4) | Reporting requirements | A description of any event which triggers a shut-off device required pursuant to § 146.88(e) and the response taken; | §5.207 (a)(2)(C)(vi) | Reporting and Record-Keeping | a description of any event that triggers a shutdown device and the response taken; and | 5.2 |
| §146.91(a)(5) | Reporting requirements | The monthly volume and/or mass of the carbon dioxide stream injected over the reporting period and the volume injected cumulatively over the life of the project; | §5.207 (a)(2)(D)(v) | Reporting and Record-Keeping | tons of CO2 injected; and | 5.2 |
| §146.91(a)(6) | Reporting requirements | Monthly annulus fluid volume added; and | §5.207 (a)(2)(C)(iv) | Reporting and Record-Keeping | monthly annulus fluid volume added; | 5.2 |
| §146.91(a)(7) | Reporting requirements | The results of monitoring prescribed under § 146.90. | §5.207 (a)(C)(vii) | Reporting and Record-Keeping | the results of monitoring prescribed under §5.206€ [§5.206(d)] of this title (relating to Permit Standards). | 5.2 |
| §146.91(b) | Reporting requirements | Report, within 30 days, the results of: | §5.207 (a)(2)(B) | Reporting and Record-Keeping | Report, within 30 days, the results of: | |
| §146.91(b)(1) | Reporting requirements | Periodic tests of mechanical integrity; | §5.207 (a)(2)(B)(i) | Reporting and Record-Keeping | Periodic tests of mechanical integrity; | 5.2 |
| §146.91(b)(2) | Reporting requirements | Any well workover; and, | §5.207 (a)(2)(B)(ii) | Reporting and Record-Keeping | Any well workover; and, | 5.2 |
| §146.91(b)(3) | Reporting requirements | Any other test of the injection well conducted by the permittee if required by the Director. | §5.207 (a)(2)(B)(iii) | Reporting and Record-Keeping | Any other test of the injection well conducted by the permittee if required by the Director. | 5.2 |
| §146.91(c) | Reporting requirements | Report, within 24 hours: | §5.207 (a)(2)(A) | Reporting and Record-Keeping | Report within 24 hours. The operator must report to the appropriate district office the discovery of any significant pressure changes or other monitoring data that indicate the presence of leaks in the well or the lack of confinement of the injected gases to the geologic storage reservoir. Such report must be made orally as soon as practicable, but within 24 hours, following the discovery of the leak, and must be confirmed in writing within five working days. | |
| §146.91(c)(1) | Reporting requirements | Any evidence that the injected carbon dioxide stream or associated pressure front may cause an endangerment to a USDW; | §5.207 (a)(2)(A) | Reporting and Record-Keeping | Report within 24 hours. The operator must report to the appropriate district office the discovery of any significant pressure changes or other monitoring data that indicate the presence of leaks in the well or the lack of confinement of the injected gases to the geologic storage reservoir. Such report must be made orally as soon as practicable, but within 24 hours, following the discovery of the leak, and must be confirmed in writing within five working days. | 5.2 |
| §146.91(c)(2) | Reporting requirements | Any noncompliance with a permit condition, or malfunction of the injection system, which may cause fluid migration into or between USDWs; | §5.207 (a)(2)(A) | Reporting and Record-Keeping | Report within 24 hours. The operator must report to the appropriate district office the discovery of any significant pressure changes or other monitoring data that indicate the presence of leaks in the well or the lack of confinement of the injected gases to the geologic storage reservoir. Such report must be made orally as soon as practicable, but within 24 hours, following the discovery of the leak, and must be confirmed in writing within five working days. | 5.2 |

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| §146.91(c)(3) | Reporting requirements | Any triggering of a shut-off system (i.e., down-hole or at the surface); | §5.207 (a)(2)(A) | Reporting and Record-Keeping | Report within 24 hours. The operator must report to the appropriate district office the discovery of any significant pressure changes or other monitoring data that indicate the presence of leaks in the well or the lack of confinement of the injected gases to the geologic storage reservoir. Such report must be made orally as soon as practicable, but within 24 hours, following the discovery of the leak, and must be confirmed in writing within five working days. | 5.2 |
| §146.91(c)(4) | Reporting requirements | Any failure to maintain mechanical integrity; or. | §5.207 (a)(2)(A) | Reporting and Record-Keeping | Report within 24 hours. The operator must report to the appropriate district office the discovery of any significant pressure changes or other monitoring data that indicate the presence of leaks in the well or the lack of confinement of the injected gases to the geologic storage reservoir. Such report must be made orally as soon as practicable, but within 24 hours, following the discovery of the leak, and must be confirmed in writing within five working days. | 5.2 |
| §146.91(c)(5) | Reporting requirements | Pursuant to compliance with the requirement at § 146.90(h) for surface air/soil gas monitoring or other monitoring technologies, if required by the Director, any release of carbon dioxide to the atmosphere or biosphere. | | | | 5.2 |
| §146.91(d) | Reporting requirements | Owners or operators must notify the Director in writing 30 days in advance of | §5.206 (i) | Commission witnessing of testing and logging. | Commission witnessing of testing and logging. The operator must provide the division with the opportunity to witness all planned well workovers, stimulation activities, other than stimulation for formation testing, and testing and logging. The operator must submit a proposed schedule of such activities to the Commission at least 30 days prior to conducting the first such activity and submit notice at least 48 hours in advance of any actual activity. Such activities shall not commence before the end of the 30 days unless authorized by the director. | |
| §146.91(d)(1) | Reporting requirements | Any planned well workover; | §5.206 (i) | Commission witnessing of testing and logging. | Commission witnessing of testing and logging. The operator must provide the division with the opportunity to witness all planned well workovers, stimulation activities, other than stimulation for formation testing, and testing and logging. The operator must submit a proposed schedule of such activities to the Commission at least 30 days prior to conducting the first such activity and submit notice at least 48 hours in advance of any actual activity. Such activities shall not commence before the end of the 30 days unless authorized by the director. | 5.2 |
| §146.91(d)(2) | Reporting requirements | Any planned stimulation activities, other than stimulation for formation testing conducted under § 146.82; and | §5.206 (i) | Commission witnessing of testing and logging. | Commission witnessing of testing and logging. The operator must provide the division with the opportunity to witness all planned well workovers, stimulation activities, other than stimulation for formation testing, and testing and logging. The operator must submit a proposed schedule of such activities to the Commission at least 30 days prior to conducting the first such activity and submit notice at least 48 hours in advance of any actual activity. Such activities shall not commence before the end of the 30 days unless authorized by the director. | 5.2 |
| §146.91(d)(2) | Reporting requirements | Any planned stimulation activities, other than stimulation for formation testing conducted under § 146.82; and | | | | |
| §146.91(d)(3) | Reporting requirements | Any other planned test of the injection well conducted by the permittee. | §5.206 (i) | Commission witnessing of testing and logging. | Commission witnessing of testing and logging. The operator must provide the division with the opportunity to witness all planned well workovers, stimulation activities, other than stimulation for formation testing, and testing and logging. The operator must submit a proposed schedule of such activities to the Commission at least 30 days prior to conducting the first such activity and submit notice at least 48 hours in advance of any actual activity. Such activities shall not commence before the end of the 30 days unless authorized by the director. | 5.2 |
| §146.91(e) | Reporting requirements | Regardless of whether a State has primary enforcement responsibility, owners or operators must submit all required reports, submittals, and notifications under subpart H of this part to EPA in an electronic format approved by EPA. | §5.207 (b)(2) | Reporting and Record-Keeping | The operators must submit all required reports, submittals, and notifications under subpart H of this part to EPA in an electronic format approved by director. | |

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| §146.91(f) | Reporting requirements | | | | | |
| §146.91(f)(1) | Reporting requirements | All data collected under § 146.82 for Class VI permit applications shall be retained throughout the life of the geologic sequestration project and for 10 years following site closure. | §5.207 (e) | Reporting and Record-Keeping | Record retention. The operator must retain all wellhead pressure records, metering records, and integrity test results for at least 10 [ten] years. The operator must retain all documentation of good faith claim to necessary and sufficient property rights to operate the geologic storage facility until the director issues the final certificate of closure in accordance with §5.206(k)(7) [§5.206(j)(7) ] of this title. | 5.2 |
| §146.91(f)(2) | Reporting requirements | Data on the nature and composition of all injected fluids collected pursuant to § 146.90(a) shall be retained until 10 years after site closure. The Director may require the owner or operator to deliver the records to the Director at the conclusion of the retention period. | | | | 5.2 |
| §146.91(f)(3) | Reporting requirements | Monitoring data collected pursuant to § 146.90(b) through (i) shall be retained for 10 years after it is collected. | | | | 5.2 |
| §146.91(f)(4) | Reporting requirements | Well plugging reports, post-injection site care data, including, if appropriate, data and information used to develop the demonstration of the alternative post-injection site care timeframe, and the site closure report collected pursuant to requirements at §§ 146.93(f) and (h) shall be retained for 10 years following site closure. | | | | 5.2 |
| §146.91(f)(5) | Reporting requirements | The Director has authority to require the owner or operator to retain any records required in this subpart for longer than 10 years after site closure. | | | | |
| §146.92 | Injection Well Plugging | Injection well plugging | §5.203 (k) | Well Plugging Plan | Injection well plugging | |
| §146.92(a) | Injection Well Plugging | Prior to the well plugging, the owner or operator must flush each Class VI injection well with a buffer fluid, determine bottomhole reservoir pressure, and perform a final external mechanical integrity test. | §5.203 (k)(2)(A) | Well Plugging Plan | flush each injection well with a buffer fluid; | 6.1.2 |
| §146.92(a) | Injection Well Plugging | Prior to the well plugging, the owner or operator must flush each Class VI injection well with a buffer fluid, determine bottomhole reservoir pressure, and perform a final external mechanical integrity test. | §5.203 (k)(2)(B) | Well Plugging Plan | performing tests or measures to determine bottomhole reservoir pressure; | 6.1.2 |
| §146.92(a) | Injection Well Plugging | Prior to the well plugging, the owner or operator must flush each Class VI injection well with a buffer fluid, determine bottomhole reservoir pressure, and perform a final external mechanical integrity test. | §5.203 (k)(2)(C) | Well Plugging Plan | performing final tests to assess mechanical integrity; and | 6.1.2 |
| §146.92(b) | Injection Well Plugging | Well plugging plan. The owner or operator of a Class VI well must prepare, maintain, and comply with a plan that is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The well plugging plan must be submitted as part of the permit application and must include the following information: | §5.203 (k) | Well Plugging Plan | Well plugging plan. The applicant must submit a well plugging plan for all injection wells and monitoring wells that penetrate the base of usable quality water that includes the following: | |
| §146.92(b) | Injection Well Plugging | Well plugging plan. The owner or operator of a Class VI well must prepare, maintain, and comply with a plan that is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The well plugging plan must be submitted as part of the permit application and must include the following information: | §5.203 (k)(1) | Well Plugging Plan | A proposal for plugging all monitoring wells that penetrate the base of usable quality water and all injection wells upon abandonment in accordance with §3.14 of this title (relating to Plugging), in addition to the requirements of this section. The proposal must include: | 6.1.3, 6.2.3, Appendix G |
| §146.92(b)(1) | Injection Well Plugging | Appropriate tests or measures for determining bottomhole reservoir pressure; | §5.203 (k)(2)(B) | Well Plugging Plan | performing tests or measures to determine bottomhole reservoir pressure; | 6.1.2, 6.2.2 |
| §146.92(b)(2) | Injection Well Plugging | Appropriate testing methods to ensure external mechanical integrity as specified in § 146.89; | §5.203 (k)(2)(C) | Well Plugging Plan | performing final tests to assess mechanical integrity; and | 6.1.2, 6.2.2 |
| §146.92(b)(3) | Injection Well Plugging | The type and number of plugs to be used; | §5.203 (k)(1)(A) | Well Plugging Plan | The type and number of plugs to be used; | 6.1.4, 6.2.4 |

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| §146.92(b)(4) | Injection Well Plugging | The placement of each plug, including the elevation of the top and bottom of each plug; | §5.203 (k)(1)(B) | Well Plugging Plan | The placement of each plug, including the elevation of the top and bottom of each plug; | 6.1.4, 6.2.4 |
| §146.92(b)(5) | Injection Well Plugging | The type, grade, and quantity of material to be used in plugging. The material must be compatible with the carbon dioxide stream; and | §5.203 (k)(1)(C) | Well Plugging Plan | The type, grade, and quantity of material to be used in plugging. The material must be compatible with the carbon dioxide stream; and | 6.1.4, 6.2.4 |
| §146.92(b)(6) | Injection Well Plugging | The method of placement of the plugs. | §5.203 (k)(1)(D) | Well Plugging Plan | The method of placement of the plugs. | 6.1.4, 6.2.4 |
| §146.92(c) | Injection Well Plugging | Notice of intent to plug. The owner or operator must notify the Director in writing pursuant to § 146.91(e), at least 60 days before plugging of a well. At this time, if any changes have been made to the original well plugging plan, the owner or operator must also provide the revised well plugging plan. The Director may allow for a shorter notice period. Any amendments to the injection well plugging plan must be approved by the Director, must be incorporated into the permit, and are subject to the permit modification requirements at § 144.39 or § 144.41 of this chapter, as appropriate. | §5.203 (k)(3)(A) | Well Plugging Plan | the operator notifies the director at least 60 days before plugging a well. At this time, if any changes have been made to the original well plugging plan, the operator must also provide a revised well plugging plan. At the discretion of the director, an operator may be allowed to proceed with well plugging on a shorter notice period; and | 6.1.2, 6.2.2 |
| §146.92(c) | Injection Well Plugging | Notice of intent to plug. The owner or operator must notify the Director in writing pursuant to § 146.91(e), at least 60 days before plugging of a well. At this time, if any changes have been made to the original well plugging plan, the owner or operator must also provide the revised well plugging plan. The Director may allow for a shorter notice period. Any amendments to the injection well plugging plan must be approved by the Director, must be incorporated into the permit, and are subject to the permit modification requirements at § 144.39 or § 144.41 of this chapter, as appropriate. | §5.203 (k)(3)(B) | Well Plugging Plan | the operator will file a notice of intention to plug and abandon (Form W-3A) a well with the appropriate Commission district office and the division in Austin at least five days prior to the beginning of plugging operations; | 6.1.2, 6.2.2 |
| §146.92(d) | Injection Well Plugging | Plugging report. Within 60 days after plugging, the owner or operator must submit, pursuant to § 146.91(e), a plugging report to the Director. The report must be certified as accurate by the owner or operator and by the person who performed the plugging operation (if other than the owner or operator.) The owner or operator shall retain the well plugging report for 10 years following site closure. | §5.203 (k)(4) | Well Plugging Plan | plugging report for monitoring wells that penetrate the base of usable quality water and all injection wells. The applicant's plan must ensure that within 30 days after plugging the operator will file a complete well plugging record (Form W-3) in duplicate with the appropriate district office. The operator and the person who performed the plugging operation (if other than the operator) must certify the report as accurate; | 6.1.3, 6.2.3 |
| §146.93 | Post-injection and site closure | Post-injection site care and site closure | §5.203 (m)(7) | Post-injection storage facility care and closure plan | consideration and documentation of: | |
| §146.93(a) | Post-injection and site closure | The owner or operator of a Class VI well must prepare, maintain, and comply with a plan for post-injection site care and site closure that meets the requirements of paragraph (a)(2) of this section and is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. | §5.203 (m) | Post-injection storage facility care and closure plan | The applicant must submit a post-injection storage facility care and closure plan. | 7.4, 7.5 |
| §146.93(a)(1) | Post-injection and site closure | The owner or operator must submit the post-injection site care and site closure plan as a part of the permit application to be approved by the Director. | | | | 7.4, 7.5 |
| §146.93(a)(2) | Post-injection and site closure | The post-injection site care and site closure plan must include the following information: | | | | |
| §146.93(a)(2)(i) | Post-injection and site closure | The pressure differential between pre-injection and predicted post-injection pressures in the injection zone(s); | §5.203 (m)(2) | Post-injection storage facility care and closure plan | The pressure differential between pre-injection and predicted post-injection pressures in the injection zone(s); | 7.2 |
| §146.93(a)(2)(ii) | Post-injection and site closure | The predicted position of the carbon dioxide plume and associated pressure front at site closure as demonstrated in the area of review evaluation required under § 146.84(c)(1); | §5.203 (m)(3) | Post-injection storage facility care and closure plan | the predicted position of the CO2 plume and associated pressure front at closure as demonstrated in the AOR evaluation required under subsection (d) of this section; | 7.3 |
| §146.93(a)(2)(iii) | Post-injection and site closure | A description of post-injection monitoring location, methods, and proposed frequency; | §5.203 (m)(4) | Post-injection storage facility care and closure plan | A description of post-injection monitoring location, methods, and proposed frequency; | 7.4.1 |
| §146.93(a)(2)(iv) | Post-injection and site closure | A proposed schedule for submitting post-injection site care monitoring results to the Director pursuant to § 146.91(e); and, | §5.203 (m)(5) | Post-injection storage facility care and closure plan | A proposed schedule for submitting post-injection site care monitoring results to the Director pursuant to § 146.91(e); and, | 7.4.1 |

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| §146.93(a)(2)(v) | Post-injection and site closure | The duration of the post-injection site care timeframe and, if approved by the Director, the demonstration of the alternative post-injection site care timeframe that ensures non-endangerment of USDWs. | §5.203 (m)(1) | Post-injection storage facility care and closure plan | a demonstration containing substantial evidence that the geologic storage project will no longer pose a risk of endangerment to USDWs at the end of the post-injection storage facility care timeframe. The demonstration must be based on significant, site-specific data and information, including all data and information collected pursuant subsections (b)-(d) of this section and §5.206(b)(5) of this title; | 7.4.2 |
| §146.93(a)(3) | Post-injection and site closure | Upon cessation of injection, owners or operators of Class VI wells must either submit an amended post-injection site care and site closure plan or demonstrate to the Director through monitoring data and modeling results that no amendment to the plan is needed. Any amendments to the post-injection site care and site closure plan must be approved by the Director, be incorporated into the permit, and are subject to the permit modification requirements at § 144.39 or § 144.41 of this chapter, as appropriate. | §5.206 (k)(1)(B) | Post-injection storage facility care and closure | The operator must update the plan in accordance with §5.207(a)(2)(D)(vi) of this title. At any time during the life of the geologic sequestration project, the operator may modify and resubmit the post-injection site care and site closure plan for the director's approval within 30 days of such change. Any amendments to the post-injection site care and site closure plan must be approved by the director, be incorporated into the permit, and are subject to the permit modification requirements in §5.202 of this title (relating to Permit Required), as appropriate. | 7.1, 7.4.2 |
| §146.93(a)(4) | Post-injection and site closure | At any time during the life of the geologic sequestration project, the owner or operator may modify and resubmit the post-injection site care and site closure plan for the Director's approval within 30 days of such change. | §5.206 (k)(1)(B) | Post-injection storage facility care and closure | The operator must update the plan in accordance with §5.207(a)(2)(D)(vi) of this title. At any time during the life of the geologic sequestration project, the operator may modify and resubmit the post-injection site care and site closure plan for the director's approval within 30 days of such change. Any amendments to the post-injection site care and site closure plan must be approved by the director, be incorporated into the permit, and are subject to the permit modification requirements in §5.202 of this title (relating to Permit Required), as appropriate. | 7.1, 7.4.2 |
| §146.93(b) | Post-injection and site closure | The owner or operator shall monitor the site following the cessation of injection to show the position of the carbon dioxide plume and pressure front and demonstrate that USDWs are not being endangered. | | | | 7.4.1 |
| §146.93(b)(1) | | Following the cessation of injection, the owner or operator shall continue to conduct monitoring as specified in the Director-approved post-injection site care and site closure plan for at least 50 years or for the duration of the alternative timeframe approved by the Director pursuant to requirements in paragraph (c) of this section, unless he/she makes a demonstration under (b)(2) of this section. The monitoring must continue until the geologic sequestration project no longer poses an endangerment to USDWs and the demonstration under (b)(2) of this section is submitted and approved by the Director. | | | | |
| §146.93(b)(2) | | If the owner or operator can demonstrate to the satisfaction of the Director before 50 years or prior to the end of the approved alternative timeframe based on monitoring and other site-specific data, that the geologic sequestration project no longer poses an endangerment to USDWs, the Director may approve an amendment to the post-injection site care and site closure plan to reduce the frequency of monitoring or may authorize site closure before the end of the 50-year period or prior to the end of the approved alternative timeframe, where he or she has substantial evidence that the geologic sequestration project no longer poses a risk of endangerment to USDWs. | | | | |
| §146.93(b)(3) | Post-injection and site closure | Prior to authorization for site closure, the owner or operator must submit to the Director for review and approval a demonstration, based on monitoring and other site-specific data, that no additional monitoring is needed to ensure that the geologic sequestration project does not pose an endangerment to USDWs. | §5.206 (k)(3) | Post-injection storage facility care and closure | Prior to closure. Prior to authorization for storage facility closure, the operator must demonstrate to the Director based on monitoring and other site-specific data, that no additional monitoring is needed to ensure that the geologic sequestration project does not pose an endangerment to USDWs. The operator must demonstrate, based on the current understanding of the site, including monitoring data and/or modeling, all of the following: | 7.4.2 |
| §146.93(b)(4) | | | | | | |

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| §146.93(c) | Post-injection and site closure | Demonstration of alternative post-injection site care timeframe. At the Director's discretion, the Director may approve, in consultation with EPA, an alternative post-injection site care timeframe other than the 50 year default, if an owner or operator can demonstrate during the permitting process that an alternative post-injection site care timeframe is appropriate and ensures non-endangerment of USDWs. The demonstration must be based on significant, site-specific data and information including all data and information collected pursuant to §§ 146.82 and 146.83, and must contain substantial evidence that the geologic sequestration project will no longer pose a risk of endangerment to USDWs at the end of the alternative post-injection site care timeframe. | | | | |
| §146.93(c)(1) | Post-injection and site closure | A demonstration of an alternative post-injection site care timeframe must include consideration and documentation of: | | | | |
| §146.93(c)(1)(i) | Post-injection and site closure | The results of computational modeling performed pursuant to delineation of the area of review under § 146.84; | §5.203 (m)(7)(A) | Post-injection storage facility care and closure plan | the results of computational modeling performed pursuant to delineation of the AOR under subsection (d) of this section; | |
| §146.93(c)(1)(ii) | Post-injection and site closure | The predicted timeframe for pressure decline within the injection zone, and any other zones, such that formation fluids may not be forced into any USDWs; and/or the timeframe for pressure decline to pre-injection pressures; | §5.203 (m)(7)(B) | Post-injection storage facility care and closure plan | the predicted timeframe for pressure decline within the injection zone, and any other zones, such that formation fluids may not be forced into any USDWs, and/or the timeframe for pressure decline to pre-injection pressures; | |
| §146.93(c)(1)(iii) | Post-injection and site closure | The predicted rate of carbon dioxide plume migration within the injection zone, and the predicted timeframe for the cessation of migration; | §5.203 (m)(7)(C) | Post-injection storage facility care and closure plan | the predicted rate of CO2 plume migration within the injection zone, and the predicted timeframe for the stabilization of the CO2 plume and associated pressure front; | |
| §146.93(c)(1)(iv) | Post-injection and site closure | A description of the site-specific processes that will result in carbon dioxide trapping including immobilization by capillary trapping, dissolution, and mineralization at the site; | §5.203 (m)(7)(D) | Post-injection storage facility care and closure plan | a description of the site-specific processes that will result in CO2 trapping including immobilization by capillary trapping, dissolution, and mineralization at the site; | |
| §146.93(c)(1)(ix) | Post-injection and site closure | A description of the well construction and an assessment of the quality of plugs of all abandoned wells within the area of review; | §5.203 (m)(7)(I) | Post-injection storage facility care and closure plan | a description of the well construction and an assessment of the quality of plugs of all abandoned wells within the AOR; | |
| §146.93(c)(1)(v) | Post-injection and site closure | The predicted rate of carbon dioxide trapping in the immobile capillary phase, dissolved phase, and/or mineral phase; | §5.203 (m)(7)(E) | Post-injection storage facility care and closure plan | the predicted rate of CO2 trapping in the immobile capillary phase, dissolved phase, and/or mineral phase; | |
| §146.93(c)(1)(vi) | Post-injection and site closure | The results of laboratory analyses, research studies, and/or field or site-specific studies to verify the information required in paragraphs (iv) and (v) of this section; | §5.203 (m)(7)(F) | Post-injection storage facility care and closure plan | the results of laboratory analyses, research studies, and/or field or site-specific studies to verify the information required in subparagraphs (D) and (E) of this paragraph; | |
| §146.93(c)(1)(vii) | Post-injection and site closure | A characterization of the confining zone(s) including a demonstration that it is free of transmissive faults, fractures, and micro-fractures and of appropriate thickness, permeability, and integrity to impede fluid (e.g., carbon dioxide, formation fluids) movement; | §5.203 (m)(7)(G) | Post-injection storage facility care and closure plan | a characterization of the confining zone(s) including a demonstration that it is free of transmissive faults, fractures, and micro-fractures and of appropriate thickness, permeability, and integrity to impede fluid (e.g., CO2, formation fluids) movement; | |
| §146.93(c)(1)(viii) | Post-injection and site closure | The presence of potential conduits for fluid movement including planned injection wells and project monitoring wells associated with the proposed geologic sequestration project or any other projects in proximity to the predicted/modeled, final extent of the carbon dioxide plume and area of elevated pressure; | §5.203 (m)(7)(H) | Post-injection storage facility care and closure plan | the presence of potential conduits for fluid movement including planned injection wells and project monitoring wells associated with the proposed geologic storage project or any other projects in proximity to the predicted/modeled, final extent of the CO2 plume and area of elevated pressure; | |
| §146.93(c)(1)(x) | Post-injection and site closure | The distance between the injection zone and the nearest USDWs above and/or below the injection zone; and | §5.203 (m)(7)(J) | Post-injection storage facility care and closure plan | the distance between the injection zone and the nearest USDWs above and/or below the injection zone; and | |
| §146.93(c)(1)(xi) | Post-injection and site closure | Any additional site-specific factors required by the Director. | §5.203 (m)(7)(K) | Post-injection storage facility care and closure plan | any additional site-specific factors required by the director; and | |
| §146.93(c)(2) | Post-injection and site closure | Information submitted to support the demonstration in paragraph (c)(1) of this section must meet the following criteria: | §5.203 (m)(8) | Post-injection storage facility care and closure plan | information submitted to support the demonstration in paragraph (1) of this subsection, which shall meet the following criteria: | |
| §146.93(c)(2)(i) | Post-injection and site closure | All analyses and tests performed to support the demonstration must be accurate, reproducible, and performed in accordance with the established quality assurance standards; | §5.203 (m)(8)(A) | Post-injection storage facility care and closure plan | all analyses and tests performed to support the demonstration must be accurate, reproducible, and performed in accordance with the established quality assurance standards; | |
| §146.93(c)(2)(ii) | Post-injection and site closure | Estimation techniques must be appropriate and EPA-certified test protocols must be used where available; | §5.203 (m)(8)(B) | Post-injection storage facility care and closure plan | estimation techniques must be appropriate and EPA-certified test protocols must be used where available; | |

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| §146.93(c)(2)(iii) | Post-injection and site closure | Predictive models must be appropriate and tailored to the site conditions, composition of the carbon dioxide stream and injection and site conditions over the life of the geologic sequestration project; | §5.203 (m)(8)(C) | Post-injection storage facility care and closure plan | predictive models must be appropriate and tailored to the site conditions, composition of the CO2 stream, and injection and site conditions over the life of the geologic storage project; | |
| §146.93(c)(2)(iv) | Post-injection and site closure | Predictive models must be calibrated using existing information (e.g., at Class I, Class II, or Class V experimental technology well sites) where sufficient data are available; | §5.203 (m)(8)(D) | Post-injection storage facility care and closure plan | predictive models must be calibrated using existing information where sufficient data are available; | |
| §146.93(c)(2)(v) | Post-injection and site closure | Reasonably conservative values and modeling assumptions must be used and disclosed to the Director whenever values are estimated on the basis of known, historical information instead of site-specific measurements; | §5.203 (m)(8)(E) | Post-injection storage facility care and closure plan | reasonably conservative values and modeling assumptions must be used and disclosed to the director whenever values are estimated on the basis of known, historical information instead of site-specific measurements; | |
| §146.93(c)(2)(vi) | Post-injection and site closure | An analysis must be performed to identify and assess aspects of the alternative post-injection site care timeframe demonstration that contribute significantly to uncertainty. The owner or operator must conduct sensitivity analyses to determine the effect that significant uncertainty may contribute to the modeling demonstration. | §5.203 (m)(8)(F) | Post-injection storage facility care and closure plan | an analysis must be performed to identify and assess aspects of the alternative PISC timeframe demonstration that contribute significantly to uncertainty. The operator must conduct sensitivity analyses to determine the effect that significant uncertainty may contribute to the modeling demonstration; | |
| §146.93(c)(2)(vii) | Post-injection and site closure | An approved quality assurance and quality control plan must address all aspects of the demonstration; and | §5.203 (m)(8)(G) | Post-injection storage facility care and closure plan | an approved quality assurance and quality control plan must address all aspects of the demonstration; and | |
| §146.93(c)(2)(viii) | Post-injection and site closure | Any additional criteria required by the Director. | §5.203 (m)(8)(H) | Post-injection storage facility care and closure plan | any additional criteria required by the director. | |
| §146.93(d) | Post-injection and site closure | Notice of intent for site closure. The owner or operator must notify the Director in writing at least 120 days before site closure. At this time, if any changes have been made to the original post-injection site care and site closure plan, the owner or operator must also provide the revised plan. The Director may allow for a shorter notice period. | §5.206 (k)(4) | Post-injection storage facility care and closure | Notice of intent for site closure. The owner or operator must notify the Director in writing at least 120 days before site closure. At this time, if any changes have been made to the original post-injection site care and site closure plan, the owner or operator must also provide the revised plan. The Director may allow for a shorter notice period. | 7.5.1 |
| §146.93(e) | Post-injection and site closure | After the Director has authorized site closure, the owner or operator must plug all monitoring wells in a manner which will not allow movement of injection or formation fluids that endangers a USDW. | §5.206 (k)(5) | Post-injection storage facility care and closure | Authorization for storage facility closure. No operator may initiate storage facility closure until the director has approved closure of the storage facility in writing. After the Director has authorized site closure, the operator must plug all monitoring wells in accordance with the approved plan required by §5.203(k) of this title. | 7.5.1, 7.5.2 |
| §146.93(f) | Post-injection and site closure | The owner or operator must submit a site closure report to the Director within 90 days of site closure, which must thereafter be retained at a location designated by the Director for 10 years. The report must include: | §5.206 (k)(6) | Post-injection storage facility care and closure | Storage facility closure report. Once the director has authorized storage facility closure, The operator must submit a site closure report to the Director within 90 days of site closure, which must thereafter be retained at a location designated by the Director for 10 years. The report must include: | 7.5.4 |
| §146.93(f)(1) | Post-injection and site closure | Documentation of appropriate injection and monitoring well plugging as specified in § 146.92 and paragraph (e) of this section. The owner or operator must provide a copy of a survey plat which has been submitted to the local zoning authority designated by the Director. The plat must indicate the location of the injection well relative to permanently surveyed benchmarks. The owner or operator must also submit a copy of the plat to the Regional Administrator of the appropriate EPA Regional Office; | §5.206 (k)(6)(A) | Post-injection storage facility care and closure | Documentation of appropriate injection and monitoring well plugging. The operator must provide a copy of a survey plat which has been submitted to the Regional Administrator of Region 6 of the United States Environmental Protection Agency. The plat must indicate the location of the injection well relative to permanently surveyed benchmarks. | 7.5.4 |
| §146.93(f)(2) | Post-injection and site closure | Documentation of appropriate notification and information to such State, local and Tribal authorities that have authority over drilling activities to enable such State, local, and Tribal authorities to impose appropriate conditions on subsequent drilling activities that may penetrate the injection and confining zone(s); and | §5.206 (k)(6)(B) | Post-injection storage facility care and closure | Documentation of appropriate notification and information to such State and local authorities that have authority over drilling activities to enable such State and local authorities to impose appropriate conditions on subsequent drilling activities that may penetrate the injection and confining zone(s); and | |
| §146.93(f)(3) | Post-injection and site closure | Records reflecting the nature, composition, and volume of the carbon dioxide stream. | §5.206 (k)(6)(C) | Post-injection storage facility care and closure | Records reflecting the nature, composition, and volume of the carbon dioxide stream. | 7.5.4 |

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| §146.93(g) | Post-injection and site closure | Each owner or operator of a Class VI injection well must record a notation on the deed to the facility property or any other document that is normally examined during title search that will in perpetuity provide any potential purchaser of the property the following information: | §5.206 (l) | Deed notation | Deed notation. The operator of a geologic storage facility must record a notation on the deed to the facility property; on any other document that is normally examined during title search; or on any other document that is acceptable to the county clerk for filing in the official public records of the county that will in perpetuity provide any potential purchaser of the property the following information: | 7.5.4 |
| §146.93(g) | Required class VI permit Information | Each owner or operator of a Class VI injection well must record a notation on the deed to the facility property or any other document that is normally examined during title search that will in perpetuity provide any potential purchaser of the property the following information: | §5.206 (l)(1) | Permit Standards | a complete legal description of the affected property; | 7.5.4 |
| §146.93(g)(1) | Post-injection and site closure | The fact that land has been used to sequester carbon dioxide; | §5.206 (l)(2) | Deed notation | The fact that land has been used to sequester carbon dioxide; | 7.5.4 |
| §146.93(g)(2) | Post-injection and site closure | The name of the State agency, local authority, and/or Tribe with which the survey plat was filed, as well as the address of the Environmental Protection Agency Regional Office to which it was submitted; and | §5.206 (l)(4) | Deed notation | the address of the office of the United States Environmental Protection Agency, Region 6, to which the operator sent a copy of the survey plat; and | 7.5.4 |
| §146.93(g)(3) | Post-injection and site closure | The volume of fluid injected, the injection zone or zones into which it was injected, and the period over which injection occurred. | §5.206 (l)(5) | Deed notation | The volume of fluid injected, the injection zone or zones into which it was injected, and the period over which injection occurred. | 7.5.4 |
| §146.93(h) | Post-injection and site closure | The owner or operator must retain for 10 years following site closure, records collected during the post-injection site care period. The owner or operator must deliver the records to the Director at the conclusion of the retention period, and the records must thereafter be retained at a location designated by the Director for that purpose. | §5.206 (m) | Retention of Records | The operator must retain for 10 years following facility closure records collected during the post-injection facility care period. The operator must deliver the records to the Director at the conclusion of the retention period, and the records must thereafter be retained at the Austin headquarters of the Commission. | 7.5.4 |
| §146.94 | Emergency and remedial response | Emergency and remedial response | §5.206 (h) | Emergency, mitigation, and remedial response | Emergency mitigation, and remedial response | |
| §146.94(a) | Emergency and remedial response | As part of the permit application, the owner or operator must provide the Director with an emergency and remedial response plan that describes actions the owner or operator must take to address movement of the injection or formation fluids that may cause an endangerment to a USDW during construction, operation, and post-injection site care periods. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. | §5.203 (l) | Emergency and remedial response plan | Emergency and remedial response plan. The applicant must submit an emergency and remedial response plan that: | |
| §146.94(a) | Emergency and remedial response | As part of the permit application, the owner or operator must provide the Director with an emergency and remedial response plan that describes actions the owner or operator must take to address movement of the injection or formation fluids that may cause an endangerment to a USDW during construction, operation, and post-injection site care periods. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. | §5.203 (l)(2) | Emergency and remedial response plan | describes actions to be taken to address escape from the permitted injection interval or movement of the injection fluids or formation fluids that may cause an endangerment to USDWs during construction, operation, closure, and post-closure periods; | 8.4 |
| §146.94(b) | Emergency and remedial response | If the owner or operator obtains evidence that the injected carbon dioxide stream and associated pressure front may cause an endangerment to a USDW, the owner or operator must: | | | | |
| §146.94(b)(1) | Emergency and remedial response | Immediately cease injection; | §5.206 (d)(2)(F)(ii)(I) | | | 8.4 |
| §146.94(b)(2) | Emergency and remedial response | Take all steps reasonably necessary to identify and characterize any release; | §5.206 (d)(2)(F)(ii)(II) | | | 8.4 |
| §146.94(b)(3) | Emergency and remedial response | Notify the Director within 24 hours; and | §5.206 (d)(2)(F)(ii)(III) | | | 8.4 |
| §146.94(b)(4) | Emergency and remedial response | Implement the emergency and remedial response plan approved by the Director. | | | | 8.4 |

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| §146.94(c) | Emergency and remedial response | The Director may allow the operator to resume injection prior to remediation if the owner or operator demonstrates that the injection operation will not endanger USDWs. | §5.206 (h)(4) | Permit Standards | Resumption of injection. The Director may allow the operator to resume injection prior to remediation if the operator demonstrates that the injection operation will not endanger USDWs. | |
| §146.94(d) | Emergency and remedial response | The owner or operator shall periodically review the emergency and remedial response plan developed under paragraph (a) of this section. In no case shall the owner or operator review the emergency and remedial response plan less often than once every five years. Based on this review, the owner or operator shall submit an amended emergency and remedial response plan or demonstrate to the Director that no amendment to the emergency and remedial response plan is needed. Any amendments to the emergency and remedial response plan must be approved by the Director, must be incorporated into the permit, and are subject to the permit modification requirements at § 144.39 or § 144.41 of this chapter, as appropriate. Amended plans or demonstrations shall be submitted to the Director as follows: | | | | 8.7 |
| §146.94(d)(1) | Emergency and remedial response | Within one year of an area of review reevaluation; | | | | 8.7 |
| §146.94(d)(2) | Emergency and remedial response | Following any significant changes to the facility, such as addition of injection or monitoring wells, on a schedule determined by the Director; or | | | | 8.7 |
| §146.94(d)(3) | Emergency and remedial response | When required by the Director. | | | | 8.7 |
| | | | §5.203 (a)(1)(A) | General | Form and filing. Each applicant for a permit to construct and operate a geologic storage facility must file an application with the division in Austin on a form prescribed by the Commission. The applicant must file the application and all attachments with the division and with EPA Region 6 in an electronic format approved by EPA. **On the same date, the applicant must file one copy with each appropriate district office and one copy with the Executive Director of the Texas Commission on Environmental Quality.** | Intro |
| | | | §5.203 (a)(1)(B) | General | Signatories to permit applications. An applicant must ensure that the application is executed by a party having knowledge of the facts entered on the form and included in the required attachments. All permit applications shall be signed as specified in this subparagraph: | Intro |
| | | | §5.203 (a)(1)(B)(i) | General | For a corporation, the permit application shall be signed by a responsible corporate officer. For the purpose of this section, a responsible corporate officer means a president, secretary, treasurer, or vice president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision making functions for the corporation, or the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25 million (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures. | |
| | | | §5.203 (a)(1)(B)(ii) | General | For a partnership or sole proprietorship, the permit application shall be signed by a general partner or the proprietor, respectively. | |
| | | | §5.203 (a)(1)(B)(iii) | General | For a municipality, State, Federal, or other public agency, the permit application shall be signed by either a principal executive officer or ranking elected official. | |

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| | | | §5.203 (a)(1)(C) | General | Certification. Any person signing a permit application or permit amendment application shall make the following certification: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." | Intro |
| | | | §5.203 (a)(2)(D) | General | A person making an application to the director for a permit under this subchapter must submit a copy of the application to the Texas Commission on Environmental Quality (TCEQ) and must submit to the director a letter of determination from TCEQ concluding that drilling and operating an anthropogenic CO2 injection well for geologic storage or constructing or operating a geologic storage facility will not impact or interfere with any previous or existing Class I injection well, including any associated waste plume, or any other injection well authorized or permitted by TCEQ. The letter must be submitted to the director before any permit under this subchapter may be issued. | Intro |
| | | | §5.203 (a)(3) | General | Application completeness. The Commission shall [may] not issue a permit before receiving a complete application. A permit application is complete when the director determines that the application contains information addressing each application requirement of the regulatory program and all information necessary to initiate the final review by the director. | |
| | | | §5.203 (a)(5) | General | If otherwise required under Occupations Code, Chapter 1001, relating to Texas Engineering Practice Act, or Chapter 1002, relating to Texas Geoscientists Practice Act, respectively, a licensed professional engineer or geoscientist must conduct the geologic and hydrologic evaluations required under this subchapter and must affix the appropriate seal on the resulting reports of such evaluations. | Intro |
| | | | §5.203 (d)(1)(A)(iii) | AOR and corrective action | The applicant must provide the name and a description of the model, software, the assumptions used to determine the AOR, and the equations solved. | 3.2 |
| | | | §5.203 (e)(1)(B)(i) | Injection well construction | The operator must ensure that injection wells are cased and the casing cemented in compliance with §3.13 of this title (relating to Casing, Cementing, Drilling, Well Control, and Completion Requirements), in addition to the requirements of this section. | 4.2.1 |
| | | | §5.203 (e)(2)(E) | Injection well construction | type of packer and packer setting depth | 4.2.3.7 |
| | | | §5.203 (f)(1)(C) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | After each casing string is set and cemented, the operator must run logs, such as a cement bond log, variable density log, and a temperature log, to ensure proper cementing. | 4.2.4.2 |
| | | | §5.203 (f)(2)(A) | Plan for logging, sampling, and testing of each injection well after permitting but prior to injection operation | Prior to operation, the operator must conduct tests to verify hydrogeologic characteristics of the injection zone. | 4.2.4.2 |
| | | | §5.203 (h)(1)(E) | Mechanical integrity testing | The operator must test injection wells after any workover that disturbs the seal between the tubing, packer, and casing in a manner that verifies internal mechanical integrity of the tubing and long string casing. | 5.4.4 |
| | | | §5.203 (h)(1)(F) | Mechanical integrity testing | An operator must either repair and successfully retest or plug a well that fails a mechanical integrity test. | |

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| | | | §5.203 (i)(2) | Operating Information | Maximum injection pressure. The director will approve a maximum injection pressure limit that: | 4.2.6 |
| | | | §5.203 (i)(2)(A) | Operating Information | Considers the risks of tensile failure and, where appropriate, geomechanical or other studies that assess the risk of tensile failure and shear failure; | 4.2.3 |
| | | | §5.203 (i)(2)(B) | Operating Information | With a reasonable degree of certainty will avoid initiation or propagation of fractures in the confining zone or cause otherwise non-transmissive faults transecting the confining zone to become transmissive; and | 4.2.6 |
| | | | §5.203 (j)(2)(D)(i) | Plan for monitoring, sampling, and testing after initiation of operation | Periodic sampling of the fluid temperature, pH, conductivity, reservoir pressure and static fluid level of the injection zone and monitoring for pressure changes, and for changes in geochemistry, in a permeable and porous formation near to and above the top confining zone; | Section 5.5.5 |
| | | | §5.203 (j)(2)(D)(ii) | Plan for monitoring, sampling, and testing after initiation of operation | Periodic monitoring of the quality and geochemistry of a USDW within the AOR and the formation fluid in a permeable and porous formation near to and above the top confining zone to detect any movement of the injected CO2 through the confining zone into that monitored formation; | 4.3.4 |
| | | | §5.203 (k)(5) | Well Plugging Plan | A plan for plugging all monitoring wells that do not penetrate the base of usable quality water in accordance with 16 TAC Chapter 76 (relating to Water Well Drillers and Water Well Pump Installers); and | TBD |
| | | | §5.203 (k)(5) | Well Plugging Plan | A plan for certifying that all monitoring wells that do not penetrate the base of usable quality water will be plugged in accordance with 16 TAC Chapter 76. | TBD |
| | | | §5.203 (l)(1) | Emergency and remedial response plan | accounts for the entire AOR, regardless of whether or not corrective action in the AOR is phased; | 3.5, 3.6 |
| | | | §5.203 (l)(3) | Emergency and remedial response plan | Includes a safety plan that includes: | |
| | | | §5.203 (l)(4) | Emergency and remedial response plan | includes a description of the training and testing that will be provided to each employee at the storage facility on operational safety and emergency response procedures to the extent applicable to the employee's duties and responsibilities. The operator must train all employees before commencing injection and storage operations at the facility. The operator must train each subsequently hired employee before that employee commences work at the storage facility. The operator must hold a safety meeting with each contractor prior to the commencement of any new contract work at a storage facility. Emergency measures specific to the contractor's work must be explained in the contractor safety meeting. Training schedules, training dates, and course outlines must be provided to Commission personnel upon request for the purpose of Commission review to determine compliance with this paragraph. | 8.5 |
| | | | §5.203 (l)(A) | Emergency and remedial response plan | emergency response procedures; | 8.4 |
| | | | §5.203 (l)(B) | Emergency and remedial response plan | provisions to provide security against unauthorized activity; | 8.4.9 |
| | | | §5.203 (l)(C) | Emergency and remedial response plan | CO2 release detection and prevention measures; | 8.4.2 |
| | | | §5.203 (l)(D) | Emergency and remedial response plan | instructions and procedures for alerting the general public and public safety personnel of the existence of an emergency; | 8.6 |
| | | | §5.203 (l)(E) | Emergency and remedial response plan | procedures for requesting assistance and for follow-up action to remove the public from an area of exposure; | 8.6 |
| | | | §5.203 (l)(F) | Emergency and remedial response plan | provisions for advance briefing of the public within the AOR on subjects such as the hazards and characteristics of CO2, | 8.6 |
| | | | §5.203 (l)(G) | Emergency and remedial response plan | the manner in which the public will be notified of an emergency and steps to be taken in case of an emergency; and | 8.6 |

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| | | | §5.203 (l)(H) | Emergency and remedial response plan | if necessary, proposed actions designed to minimize and respond to risks associated with potential seismic events, including seismic monitoring; and | 8.6 |
| | | | §5.203 (m)(6) | Post-injection storage facility care and closure plan | the estimated cost of proposed post-injection storage facility care and closure; and | 9.2 |
| | | | §5.206 (a) | Permit Standards | Each condition applicable to a permit shall be incorporated into the permit either expressly or by reference. If incorporated by reference, a specific citation to the rules in this chapter shall be given in the permit. The requirements listed in this section are directly enforceable regardless of whether the requirement is a condition of the permit. | |
| | | | §5.206 (b) | Permit Standards | General criteria. The director may issue a permit under this subchapter if the applicant demonstrates and the director finds that: | |
| | | | §5.206 (b)(1) | Permit Standards | the injection and geologic storage of anthropogenic CO2 will not endanger or injure any existing or prospective oil, gas, geothermal, or other mineral resource, or cause waste as defined by Texas Natural Resources Code, §85.046(11); | 1.7 |
| | | | §5.206 (b)(10) | Permit Standards | the applicant has paid the fees required in §5.205(a) of this title (relating to Fees, Financial Responsibility, and Financial Assurance); | |
| | | | §5.206 (b)(11) | Permit Standards | the director has determined that the applicant has sufficiently demonstrated financial responsibility as required in §5.205(b) of this title; and | |
| | | | §5.206 (b)(12) | Permit Standards | the applicant submitted to the director financial assurance in accordance with §5.205(c) of this title. | 9.2 |
| | | | §5.206 (b)(2) | Permit Standards | with proper safeguards, both USDWs and surface water can be adequately protected from CO2 migration or displaced formation fluids; | |
| | | | §5.206 (b)(3) | Permit Standards | the injection of anthropogenic CO2 will not endanger or injure human health and safety; | |
| | | | §5.206 (b)(4) | Permit Standards | the reservoir into which the anthropogenic CO2 is injected is suitable for or capable of being made suitable for protecting against the escape or migration of anthropogenic CO2 from the storage reservoir; | |
| | | | §5.206 (b)(5)(B) | Permit Standards | a confining zone that is laterally continuous and free of known transecting transmissive faults or fractures over an area sufficient to contain the injected CO2 stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without compromising the confining zone or causing the movement of fluids that endangers USDWs; | 1.3.3, 1.4.2, 1.5.3, 4.2.6 |
| | | | §5.206 (b)(6) | Permit Standards | the applicant for the permit meets all of the other statutory and regulatory requirements for the issuance of the permit; | |
| | | | §5.206 (b)(7) | Permit Standards | the applicant has provided a letter from the Groundwater Advisory Unit of the Oil and Gas Division in accordance with §5.203(o) of this title (relating to Application Requirements); | TBD |
| | | | §5.206 (b)(8) | Permit Standards | the applicant has provided a letter of determination from TCEQ concluding that drilling and operating an anthropogenic CO2 injection well for geologic storage or constructing or operating a geologic storage facility will not impact or interfere with any previous or existing Class I injection well, including any associated waste plume, or any other injection well authorized or permitted by TCEQ; | TBD |
| | | | §5.206 (b)(9) | Permit Standards | the applicant has provided a signed statement that the applicant has a good faith claim to the necessary and sufficient property rights for construction and operation of the geologic storage facility for at least the first five years after initiation of injection in accordance with §5.203(d)(1)(A) of this title; | TBD |
| | | | §5.206 (c)(1) | Permit Standards | Construction of anthropogenic CO 2 injection wells must meet the criteria in §5.203(e) of this title. | 4.1 |

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| | | | §5.206 (c)(2) | Permit Standards | Within 30 days after the completion or conversion of an injection well subject to this subchapter, the operator must file with the division a complete record of the well on the appropriate form showing the current completion. | 4.2.2 |
| | | | §5.206 (c)(3) | Permit Standards | Except in the case of an emergency repair, the operator of a geologic storage facility must notify the director in writing at least 30 days prior to conducting any well workover that involves running tubing and setting packers, beginning any workover or remedial operation, or conducting any required pressure tests or surveys. Such activities shall not commence before the end of the 30 days unless authorized by the director. In the case of an emergency repair, the operator must notify the director of such emergency repair as soon as reasonably practical. | 5.2 |
| | | | §5.206 (d) | Permit Standards | Operating a geologic storage facility. | |
| | | | §5.206 (d)(1) | Permit Standards | Operating plan. The operator must maintain and comply with the approved operating plan. | |
| | | | §5.206 (d)(2) | Permit Standards | Operating criteria. | |
| | | | §5.206 (d)(2)(B) | Permit Standards | The total volume of CO2 injected into the storage facility must be metered through a master meter or a series of master meters. The volume and/or mass of CO2 injected into each injection well must be metered through an individual well meter. If mass is determined using volume, the operator must provide calculations. | 5.5.1 |
| | | | §5.206 (d)(2)(C) | Permit Standards | The operator must comply with a maximum surface injection pressure limit approved by the director and specified in the permit. In approving a maximum surface injection pressure limit, the director must consider the results of well tests and, where appropriate, geomechanical or other studies that assess the risks of tensile failure and shear failure. The director must approve limits that, with a reasonable degree of certainty, will avoid initiation or propagation of fractures in the confining zone or cause otherwise non-transmissive faults or fractures transecting the confining zone to become transmissive. In no case may injection pressure cause movement of injection fluids or formation fluids in a manner that endangers USDWs. The Commission shall include in any permit it might issue a limit of 90 percent of the fracture pressure to ensure that the injection pressure does not initiate new fractures or propagate existing fractures in the injection zone(s). In no case may injection pressure initiate fractures in the confining zone(s) or cause the movement of injection or formation fluids that endangers a USDW. The director may approve a plan for controlled artificial fracturing of the injection zone. | 4.2.6 |
| | | | §5.206 (d)(2)(E) | Permit Standards | The operator must install and use continuous recording devices to monitor the injection pressure, and the rate, volume, and temperature of the CO2 stream. The operator must monitor the pressure on the annulus between the tubing and the long string casing. The operator must continuously record, continuously monitor, or control by a preset high-low pressure sensor switch the wellhead pressure of each injection well. | 5.5.1 |
| | | | §5.206 (e) | Permit Standards | Monitoring, sampling, and testing requirements. | |
| | | | §5.206 (e)(1) | Permit Standards | The operator of an anthropogenic CO2 injection well must maintain and comply with the approved monitoring, sampling, and testing plan to verify that the geologic storage facility is operating as permitted and that the injected fluids are confined to the injection zone. | |
| | | | §5.206 (e)(2) | Permit Standards | All permits shall include the following requirements: | |
| | | | §5.206 (e)(2)(A) | Permit Standards | the proper use, maintenance, and installation of monitoring equipment or methods; | |

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| | | | §5.206 (e)(2)(B) | Permit Standards | monitoring including type, intervals, and frequency sufficient to yield data that are representative of the monitored activity including, when required, continuous monitoring; | 5.2 |
| | | | §5.206 (e)(2)(C) | Permit Standards | reporting no less frequently than as specified in §5.207 of this title (relating to Reporting and Record-Keeping). | 5.2 |
| | | | §5.206 (e)(3) | Permit Standards | The director may require additional monitoring as necessary to support, upgrade, and improve computational modeling of the AOR evaluation and to determine compliance with the requirement that the injection activity not allow movement of fluid that would endanger USDWs. | |
| | | | §5.206 (e)(4) | Permit Standards | The director may require measures and actions designed to minimize and respond to risks associated with potential seismic events, including seismic monitoring. | |
| | | | §5.206 (f)(1) | Permit Standards | The operator must maintain and comply with the approved mechanical integrity testing plan submitted in accordance with §5.203(j) of this title. | 5.4.4 |
| | | | §5.206 (f)(3) | Permit Standards | The operator must either repair and successfully retest or plug a well that fails a mechanical integrity test. | |
| | | | §5.206 (h)(2)(A) | Permit Standards | The operator must prepare and implement a plan to train and test each employee at the storage facility on occupational safety and emergency response procedures to the extent applicable to the employee's duties and responsibilities. The operator must make copies of the plan available at the geological storage facility. The operator must train all employees before commencing injection and storage operations at the facility. The operator must train each subsequently hired employee before that employee commences work at the storage facility. | 8.5 |
| | | | §5.206 (h)(2)(B) | Permit Standards | The operator must hold a safety meeting with each contractor prior to the commencement of any new contract work at a storage facility. The operator must explain emergency measures specific to the contractor's work in the contractor safety meeting. | 8.5 |
| | | | §5.206 (h)(2)(C) | Permit Standards | The operator must provide training schedules, training dates, and course outlines to Commission personnel annually and upon request for the purpose of Commission review to determine compliance with this paragraph. | 8.5 |
| | | | §5.206 (j) | Permit Standards | Schedule of compliance: The permit may, when appropriate, specify a schedule of compliance leading to compliance with all provisions of this subchapter and Chapter 3 of this title. | |
| | | | §5.206 (j)(i) | Permit Standards | Any schedule of compliance shall require compliance as soon as possible, and in no case later than three years after the effective date of the permit. | |
| | | | §5.206 (j)(ii) | Permit Standards | If the schedule of compliance is for a duration of more than one year from the date of permit issuance, then interim requirements and completion dates (not to exceed one year) must be incorporated into the compliance schedule and permit. | |
| | | | §5.206 (j)(iii) | Permit Standards | Progress reports must be submitted no later than 30 days following each interim date and the final date of compliance. | |
| | | | §5.206 (k)(1)(A) | Permit Standards | The operator of an injection well must maintain and comply with the approved post-injection storage facility care and closure plan. | 7.4, 7.5 |
| | | | §5.206 (k)(1)(C) | Permit Standards | Upon cessation of injection, the operator of a geologic storage facility must either submit an amended plan or demonstrate to the director through monitoring data and modeling results that no amendment to the plan is needed. | 7.1, 7.4.2 |
| | | | §5.206 (k)(3)(A) | Permit Standards | the estimated magnitude and extent of the facility footprint (the $CO_2$ plume and the area of elevated pressure); | 7.3 |
| | | | §5.206 (k)(3)(B) | Permit Standards | that there is no leakage of either $CO_2$ or displaced formation fluids that will endanger USDWs; | 7.4.2 |

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| | | | §5.206 (k)(3)(C) | Permit Standards | that the injected or displaced fluids are not expected to migrate in the future in a manner that encounters a potential leakage pathway into USDWs; | 7.4.1 |
| | | | §5.206 (k)(3)(D) | Permit Standards | that the injection wells at the site completed into or through the injection zone or confining zone will be plugged and abandoned in accordance with these requirements; and | 7.5.2 |
| | | | §5.206 (k)(3)(E) | Permit Standards | any remaining facility monitoring wells will be properly plugged or are being managed by a person and in a manner approved by the director. | 7.5.2 |
| | | | §5.206 (n) | Permit Standards | Signs. The operator must identify each location at which geologic storage activities take place, including each injection well, by a sign that meets the requirements specified in §3.3(1), (2), and (5) of this title (relating to Identification of Properties, Wells, and Tanks). In addition, each sign must include a telephone number where the operator or a representative of the operator can be reached 24 hours a day, seven days a week in the event of an emergency. | |
| | | | §5.206 (o) | Permit Standards | Other permit terms and conditions. | |
| | | | §5.206 (o)(1) | Permit Standards | Protection of USDWs. In any permit for a geologic storage facility, the director must impose terms and conditions reasonably necessary to protect USDWs. Permits issued under this subchapter continue in effect until revoked, modified, or terminated by the Commission. The operator must comply with each requirement set forth in this subchapter as a condition of the permit unless modified by the terms of the permit. | |
| | | | §5.206 (o)(2) | Permit Standards | Other conditions. The following conditions shall also be included in any permit issued under this subchapter. | |
| | | | §5.206 (o)(2)(A) | Permit Standards | Duty to comply. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. However, the permittee need not comply with the provisions of the permit to the extent and for the duration such noncompliance is authorized in an emergency permit under 40 CFR §144.34. | |
| | | | §5.206 (o)(2)(B) | Permit Standards | Need to halt or reduce activity not a defense. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit. | |
| | | | §5.206 (o)(2)(C) | Permit Standards | Duty to mitigate. The permittee shall take all reasonable steps to minimize or correct any adverse impact on the environment resulting from noncompliance with this permit. | |
| | | | §5.206 (o)(2)(D) | Permit Standards | Proper operation and maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit. | |
| | | | §5.206 (o)(2)(E) | Permit Standards | Property rights not conveyed. The issuance of a permit does not convey property rights of any sort, or any exclusive privilege. | |
| | | | §5.206 (o)(2)(F) | | Activities not authorized. The issuance of a permit does not authorize any injury to persons or property or invasion of other private rights, or any infringement of State or local law or regulations. | |

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| | | | §5.206 (o)(2)(G) | Permit Standards | Coordination with exploration. The permittee of a geologic storage well shall coordinate with any operator planning to drill through the AOR to explore for oil and gas or geothermal resources and take all reasonable steps necessary to minimize any adverse impact on the operator's ability to drill for and produce oil and gas or geothermal resources from above or below the geologic storage facility. | 1.7 ??? |
| | | | §5.206 (o)(2)(H) | Permit Standards | Duty to provide information. The operator shall furnish to the Commission, within a time specified by the Commission, any information that the Commission may request to determine whether cause exists for modifying, revoking and reissuing, or terminating the permit, or to determine compliance with the permit. The operator shall also furnish to the Commission, upon request, copies of records required to be kept under the conditions of the permit. | |
| | | | §5.206 (o)(2)(I) | Permit Standards | Inspection and entry. The operator shall allow any member or employee of the Commission, on proper identification, to: | |
| | | | §5.206 (o)(2)(I)(i) | Permit Standards | enter upon the premises where a regulated activity is conducted or where records are kept under the conditions of the permit; | |
| | | | §5.206 (o)(2)(I)(ii) | Permit Standards | have access to and copy, during reasonable working hours, any records required to be kept under the conditions of the permit; | |
| | | | §5.206 (o)(2)(I)(iii) | Permit Standards | inspect any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under the permit; and | |
| | | | §5.206 (o)(2)(iv) | Permit Standards | sample or monitor any substance or parameter for the purpose of assuring compliance with the permit or as otherwise authorized by the Texas Water Code, §27.071, or the Texas Natural Resources Code, §91.1012. | |
| | | | §5.207 (a)(2)(C)(v) | Reporting and Record-Keeping | A description of any event that exceeds operating parameters for annulus pressure or injection pressure specified in the permit; | 5.2 |
| | | | §5.207 (a)(D) | Reporting and Record-Keeping | Annual reports. The operator must submit an annual report detailing: | 5.2 |
| | | | §5.207 (d) | Reporting and Record-Keeping | Certification. All reports required by permits and other information requested by the director under this subchapter, shall be certified as follows: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." | Cover Pages |
| | | | §5.207 (c)(2) | Reporting and Record-Keeping | Changes to authorization. If an authorization under paragraph (1) of this subsection is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph (1) of this subsection must be submitted to the director prior to or together with any reports, information, or applications to be signed by an authorized representative. | |
| | | | §5.207 (a)(2)(D)(i) | Reporting and Record-Keeping | corrective action performed; | |
| | | | §5.207 (c)(1) | Reporting and Record-Keeping | Reports. All reports required by permits and other information requested by the director, shall be signed by a person described in §5.203(a)(1)(B) of this title, or by a duly authorized representative of that person. A person is a duly authorized representative only if: | |
| | | | §5.207 (c) | Reporting and Record-Keeping | Signatories to reports. | |
| | | | §5.207 (c)(1)(A) | Reporting and Record-Keeping | the authorization is made in writing by a person described in §5.203(a)(1)(B) of this title; | |

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| | | | §5.207 (c)(1)(B) | Reporting and Record-Keeping | the authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility; and | |
| | | | §5.207 (b)(1) | Reporting and Record-Keeping | The operator must report the results of injection pressure and injection rate monitoring of each injection well on Form H-10, Annual Disposal/Injection Well Monitoring Report, and the results of internal mechanical integrity testing on Form H-5, Disposal/Injection Well Pressure Test Report. Operators must submit other reports in a format acceptable to the Commission. At the discretion of the director, other formats may be accepted. | |
| | | | §5.207 (c)(1)(C) | Reporting and Record-Keeping | the written authorization is submitted to the director. | |

# SECTION 0 – INTRODUCTION

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## Project Overview

The International Energy Agency (IEA) states that in 2021 just over 40 million metric tons per year (MMT/yr) of $CO_2$ were captured worldwide.[1] By 2070, the world will need to capture and store more than 10,000 MMT/yr of $CO_2$ to meet the Sustainable Development Scenario plan outlined by the IEA.[2] To meet these climate goals, real projects and investment are paramount—such as carbon capture, which is becoming an essential addition to industrial processes emitting carbon dioxide into the atmosphere.[3]

[redacted] Orchard Storage team members have extensive expertise in the capture, transport, and geologic storage of $CO_2$. Carbon capture and storage represent meaningful, physical reductions in $CO_2$ emission—to dramatically decrease Scope 1, 2, and 3 emissions, as described in Figure 0-1.

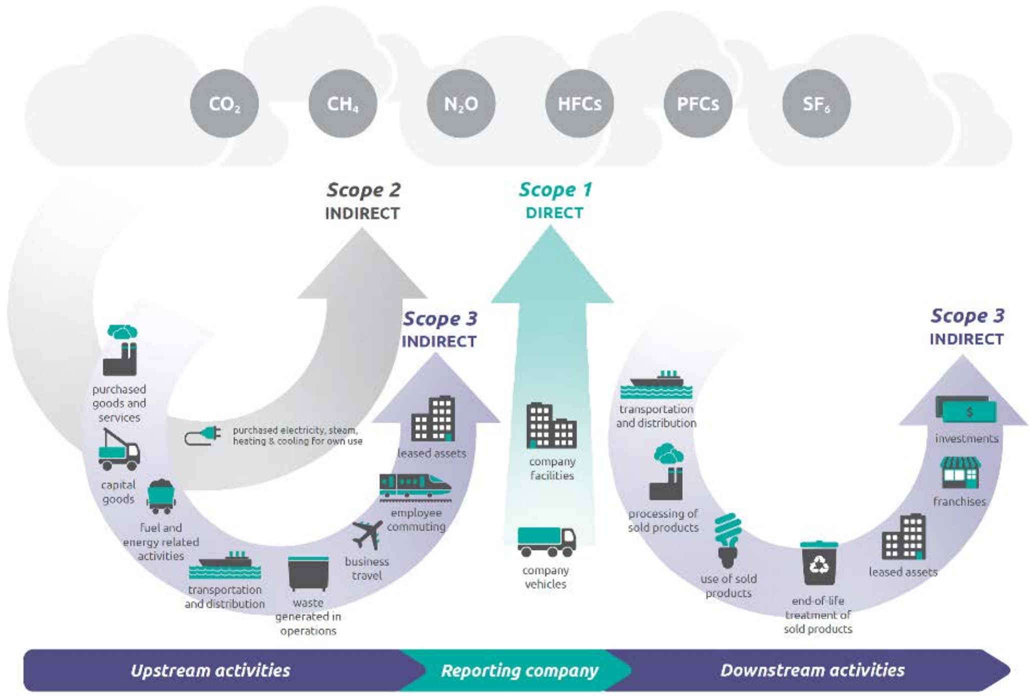


Figure 0-1 – Emission Sources[4]

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[1] https://www.iea.org/reports/about-ccus
[2] https://www.iea.org/reports/about-ccus
[redacted]
[4] https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf, page 5

The Orchard Project is being developed to accommodate and sequester, in secure geologic storage, anthropogenic $CO_2$ sourced regionally from various emitters. The Orchard Project plans to use multiple wells at the storage site to accommodate the captured $CO_2$ volumes. The extensive screening process for Orchard's site selection resulted in a site that meets Underground Injection Control (UIC) requirements with minimal existing wellbores, an injection interval with requisite and appropriate reservoir properties, and substantial sealing intervals. The storage site is also relatively near existing $CO_2$ pipeline infrastructure to accommodate the economic delivery of sourced $CO_2$ volumes to the Orchard Project.

[redacted] he $CO_2$ injection well is designed to meet the requirements of American Petroleum Institute (API) 1171, along with the regulatory requirements outlined in 16 Texas Administrative Code (TAC) **§5.206(c)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.86**].

[redacted]

[redacted]

[redacted] *Section 1 – Site Characterization* of this permit application will detail the geology and reservoir characterization of this project.

[redacted]

## Project Key Attributes

- [redacted]

5 [redacted]

6 https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

- [redacted]
- No major shallow faults, which may cause $CO_2$ to breach containment and contaminate Underground Sources of Drinking Water (USDWs), were observed.
- No artificial penetrations, which could cause $CO_2$ to breach containment and contaminate USDWs, were identified in the $CO_2$ plume area of review (AOR) of Orchard [redacted].
- No Environmental Protection Agency (EPA)-identified environmental justice communities exist within the Orchard Project area.
- No adverse disproportionate effects on populations in environmental justice areas will arise from the construction, operation, and maintenance of the project.

## Pore Space Agreement Discussion

[redacted]

## Proposed $CO_2$ Sequestration System Discussion

[redacted]

### Injectate Information

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

**Surface Facility Details**

[redacted]

## Site Suitability

[redacted]

[redacted]

- [redacted]

[redacted]

[redacted]

In compliance with regulations, an evaluation of the proposed site ("Site Suitability") was conducted by assessing factors such as:

- Location of the proposed project site
- Consideration of the project area relative to federal sites/buildings/facilities, etc.
- Endangered species research
- Flood zone
- Existing infrastructure, surface, and subsurface mines or quarries
- Faults or fractures in the project area based on seismic analysis or geophysical well log characterization
- State or federal subsurface cleanup sites within the project area
- Environmental justice issues
- Artificial penetrations in the project area
- Drinking water in the project area
- Any other site-related issues

The results of this site assessment make up the content of this permit application.

## Summary

[redacted]

This permit application includes a detailed assessment of the overall geologic environment (*Section 1 – Site Characterization*) and the resulting plume model and results (*Section 2 – Plume Model*) used to determine the arial extent of the plume and the resulting AOR. As detailed in *Section 3 – Area of Review and Corrective Action Plan*, the AOR for Orchard [redacted] Well design and construction plans that take into consideration the needs of the project, the modeling results, and the requirements to ensure the protection of the USDWs are detailed in *Section 4 – Engineering Design and Operating Strategy*.

To ensure that the $CO_2$ plume is being monitored over the life of the project, a detailed Testing and Monitoring Plan has been assembled in *Section 5 – Testing and Monitoring Plan*. [redacted]

The proposed Orchard [redacted] project addresses all the requirements for a Class VI sequestration well. This well is ideally located to sequester significant amounts of $CO_2$ with minimal impact to the surface and surrounding communities.

## Required Administrative Information

### General Application Information

Injection Well Information:

| | |
|---|---|
| Well Name and Number | Orchard [redacted] |
| County | [redacted] |
| Location | |
| Latitude and Longitude | |

Applicant:

| | |
|---|---|
| Name | Orchard Storage Company LLC |
| Address | 620 N. Grant Street<br>Odessa, Texas 79761 |
| Facility contacts | [redacted] |
| | [redacted] |
| Ownership Status | [redacted] |
| Entity Status | [redacted] |

Standard Industrial Classification (SIC) Codes:

- 4925 – Mixed, Manufactured, or Liquified Petroleum Gas Production and/or Distribution
- 4953 – Refuse Systems (nonhazardous waste disposal sites)

This facility is not located on federal or tribal lands.

[redacted]

[redacted]

[redacted]

# SECTION 1 – SITE CHARACTERIZATION

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## Figures

[redacted]

[redacted]

[redacted]

## Tables

[redacted]

## 1.1. Overview

This site characterization for Orchard Storage Company LLC's (Orchard Storage) Orchard #2 well was prepared to meet the requirements of 16 Texas Administrative Code (TAC) **§5.203 (c)(2)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.82(a)(3)**]. This section describes the regional and site geology for the proposed location. This site characterization incorporates analysis from multiple data types, including core, well logs, seismic (2D), academic and professional publications (e.g., regional geologic frameworks), and nearby subsurface analogs.

## 1.2. Regional Geology

### 1.2.1 Regional Geologic Setting

[redacted]

[redacted]

[redacted]

### 1.2.2 Regional Stratigraphic Model

[redacted]

[redacted]

Each stratigraphic succession reflects a composite of high-frequency cyclicity incorporating lowstand, transgressive, and highstand system tracts across the region. These successions are reflective of paleo-topographic changes across the area caused by sea-level fluctuation, subsidence, water depth, and compaction forces. [redacted]

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### 1.2.3 Regional Depositional Model

[redacted]

[redacted]

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### 1.2.4 Major Stratigraphic Units

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## 1.3. Site Geology

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### 1.3.1 Subsurface Data and Methods

Well Logs

Digital well log files (.las file format) were used for several site characterization tasks, including stratigraphic top determinations, petrophysical calculations, integration to the core and seismic data, and creation of a 3D conceptual and numerical model (“geomodel”). These well logs were the primary source for understanding vertical and lateral rock quality changes in the injection and confining zones. [redacted]

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Seismic

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### 1.3.2 Injection Zone

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### 1.3.3 Primary Upper Confining Zone

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Lithology

The primary upper confining zone in Orchard can prevent the migration of injected $CO_2$ from the injection zone to shallower geologic intervals and USDWs. The sealing integrity is high due to the dominant lithological characteristics based on core, well log, and subsurface analog data.

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Porosity

Density porosity was derived using the bulk density log and an estimated matrix density for the upper confining zone. [redacted]

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Water Saturation

The confining zone is assigned 100% water saturation with the same salinity as the injection zone.

### 1.3.4 Primary Lower Confining Zone

[redacted]

[redacted]

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[redacted]

Porosity
Density porosity was derived using the bulk density log and an estimated matrix density for this confining zone. [redacted]

[redacted]

[redacted]

Permeability (Horizontal and Vertical)
[redacted]

Water Saturation
The confining zone is assigned 100% water saturation with the same salinity as the injection zone.

## 1.4. Site Structure, Stratigraphy, and Deposition: 2D Seismic Integration

[redacted]

[redacted]

[redacted]

[redacted]

Tying well log data to seismic surveys involved forward modeling of a synthetic seismogram, derived from sonic and density well-log data. The seismogram was used to generate "normal reflectivity," reflection coefficients, and acoustic-impedance log curves. [redacted]

- [redacted]

The seismic-to-well tie allowed for selection of seismic horizons that either matched well log data and well tops, or were not observable on well log data or current well tops—but were visible on the seismic data. [redacted]

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### 1.4.1 Horizon Interpretation

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### 1.4.2 Fault Interpretation

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## 1.5. Geomechanics

[redacted]

- [redacted]

### 1.5.1 Elastic Moduli

[redacted]

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[redacted]

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### 1.5.2 Local Stress Conditions

[redacted]

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A method to predict a simplified fracture gradient is the standard Eaton equation (i.e., $S_h$ minimum horizontal stress, or fracture closure pressure). Eaton's equation is shown below:

$$P_f = (v / 1 - v) * (S_v - P_p) + P_p$$

*Where:*
*$P_f$ = fracture closure pressure gradient*
*v = Poisson's ratio*
*$S_v$ (overburden stress gradient) = 1.0*
*$P_p$ (pore pressure gradient) = 0.433.*

Biot's constant was based on approximate dynamic elastic moduli calculated using the equation based on data from Detournay & Cheng (1993):

$$a = 0.62 + 0.935 * phi$$

*Where phi = porosity.*

The minimum stress equation (Barree, 2009) used to estimate the fracture closure pressure is below:

$$Pf = (v / 1 - v) * (S_v - a_v * P_p) + a_h * P_p \cancel{[+ \varepsilon_x * E + \sigma_t]}$$

*Where:*
*$P_f$ = fracture closure pressure gradient*
*v = Poisson's ratio*
*$S_v$ (overburden stress gradient) = 1.0*
*$P_p$ (pore pressure gradient) = 0.433*
*a = Biot's constant (vertical is calculated and horizontal = 1).*

(Not used, but shown above, $\varepsilon_x$ is regional horizontal strain, E is Young's modulus, and $\sigma_t$ is regional horizontal tectonic stress.[1])

The following dynamic elastic moduli (for well API# 42-165-38804) were calculated using well logs using methods summarized in Crain's Petrophysical Handbook:

- Shear Modulus (G)
- Poisson's ratio (*v*)

---

[redacted]

- Young's modulus (E)
- Bulk modulus (Kb)
- Biot's constant (*α*)
- Minimum horizontal stress ($S_h$)

### 1.5.3 Injection Zone Fracture Gradient

[redacted]

[redacted]

[redacted]

[redacted]

Table 1-8 – Mohr Circle Analysis Parameters

| Parameter | Value |
|---|---|
| Expected Angle of Internal Friction | 30° |
| Coefficient of Internal Friction | 0.6 |
| Lithostatic Stress Gradient | 1.0 psi/ft |
| Pore Pressure Gradient | 0.433 psi/ft |
| Confining Pressure | 1,180 psi |
| Cohesive Strength | 2,175 psi |
| Tensile Strength | 1,087 psi |

[redacted]

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## 1.6. Geochemistry

This section discusses the fluid and solid-phase geochemistry in the Orchard site and wider area.

### 1.6.1 Fluid Chemistry (Injection Zone)

[redacted]

[redacted]

[redacted]

[redacted]

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[redacted]

### 1.6.2 Rock Chemistry (Injection Zone and Upper Confining Zone)

[redacted]

[redacted]

[redacted]

[redacted]

### 1.6.3 Simulated Interactions (Injection Zone and Upper Confining Zone)

[redacted]

[redacted]

## 1.7. Site Evaluation of Mineral Resources

[redacted]

[redacted]

[redacted]

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[redacted]

## 1.8. Seismic History

[redacted]

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[redacted]

## 1.9. Site Suitability

[redacted]

### 1.9.1 Lithofacies

[redacted]

### 1.9.2 Leakage Pathways

[redacted]

### 1.9.3 Hydrology and Hydrogeology

[redacted]

[redacted]

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- [redacted]

### 1.9.4 Total Storage Capacity

[redacted]

[redacted]

### 1.9.5 Injection Capacity

Several iterations of the porosity and permeability model have incorporated site-specific data, regional geologic frameworks, and subsurface analog information to reduce uncertainty around the quality of the injection zone in the Orchard area. [redacted]

### 1.9.6 Secondary Confinement

[redacted]

---

[2]DOE's NETL developed CO2-SCREEN ($CO_2$ Storage prospeCtive Resource Estimation Excel aNalysis) to screen saline formations for prospective $CO_2$ storage resources.

## 1.10. Further Site Characterization

Several topics below are opportunities for future work to increase the accuracy and reduce the uncertainty of the Orchard site characterization. [redacted]

### 1.10.1 Core

Further core analysis will be performed when confining and injection zone cores are obtained. Testing may include thin-section description, mercury injection, core description (confining zone), XRD, scanning electron microscopy, relative permeability ($CO_2$, brine), etc.

### 1.10.2 Sequence Stratigraphy

[redacted]

### 1.10.3 Facies

[redacted]

### 1.10.4 Secondary Injection Targets

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# SECTION 2 – PLUME MODEL

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**Figures**

[redacted]

## Tables

[redacted]

## 2.1 Introduction

This section discusses key details of the plume model. The model characterizes the performance of $CO_2$ injection wells, the 3D spatial distribution of the $CO_2$ plume, and the associated pressure front over time. It incorporates hydrogeologic data with subsurface flow physics to model the significant physical processes that affect the plume and pressure front evolution. The distribution of the plume and pressure front defines the area of review (AOR) for the well, a corrective action plan if necessary, and the overall viability of the project.

While the following discussion specifically focuses on the proposed [redacted] well, [redacted] This also helps to verify that the pressure of the reservoir remains below the fracture pressure gradient limits of the formation during combined injection operations.

The modeling software used to evaluate this project was Computer Modelling Group's GEM 2022.30 (GEM) simulator. Computer Modelling Group (CMG) has put together one of the most accurate and technically sound reservoir simulation software packages for conventional, unconventional, and secondary recovery. GEM uses equation-of-state (EOS) algorithms and some of the most advanced computational methods to evaluate compositional, chemical, and geochemical processes and characteristics, to produce highly accurate and reliable simulation models for carbon sequestration.

For purposes of injection into a reservoir, $CO_2$ can be a relatively complex component in the supercritical phase as seen in downhole conditions. The GEM simulator utilizes the compositional methods described, along with equations specific to $CO_2$, to effectively model and simulate plume behavior within the injection intervals.

[redacted]

## 2.2 Model Inputs

### 2.2.1 Trapping Mechanisms

The $CO_2$ injected into the reservoir will take the form of a mobile, $CO_2$-rich supercritical phase. In this phase, the $CO_2$ will displace reservoir fluids as it moves laterally and vertically into the reservoir. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Movement of the $CO_2$ phase does not continue indefinitely. As the $CO_2$ moves both vertically and horizontally, various trapping mechanisms immobilize the $CO_2$ within the reservoir. [redacted]

2.2.1.1 Upper Confining Zone

[redacted]

2.2.1.2 Residual Gas Trapping

While the $CO_2$ will remain in the supercritical phase within the storage interval ("reservoir"), the gas-liquid relative-permeability relationships will govern fluid flow between the $CO_2$ and liquid phases present. [redacted]

[redacted] (Land C. S., 1971).

[redacted] Land C. , 1968). [redacted]

[redacted] (Keelan, 1975). [redacted]

In [redacted]

[redacted]

[redacted]

[redacted]

### 2.2.1.3 Solubility Trapping in Brines

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#### 2.2.1.5 Structural Trapping

[redacted]

#### 2.2.1.6 Geochemical Trapping

Mineral trapping can also occur due to the adsorption of $CO_2$ onto clay minerals. Once hysteresis and solubility trapping have been included in the model, geochemical formulae can be added through an internal geochemistry database to describe mineral trapping reactions. For aqueous reactions, the following three formulae can be used:

$$CO_2(aq) + H_2O = H^+ + HCO_3^-$$
$$CO_3^{-2} + H^+ = HCO_3^-$$
$$OH^- + H^+ = H_2O$$

Those common ionic reactions can occur in the reservoir between water and/or $CO_2$. The following formulae show the mineral reactions that may be used within the model. Each of these is a common mineral that may be found in carbonates in an underground aquifer and cause the precipitation of carbon oxides in a solid state:

$$Anhydrite\ (CaSO_4) = \ Ca^{2+} + \ SO_4^{2-}$$
$$Calcite\ (CaCO_3) + H^+ = Ca^{2+} + HCO_3^-$$
$$Dolomite\ (CaMg(CO_3)_2) + 2H^+ = Ca^{2+} + 2(HCO_3^-) + Mg^{2+}$$
$$Illite\ (K_6Mg_{25}Al_{2.3}Si_{3.5}O_{10}(OH)_2) + 8H^+ = 2.3Al^{3+} + 5H_2O + 0.6K^+ + 0.25Mg^{2+} + 3.5SiO_2$$
$$Kaolinite\ \left(Al_2Si_2O_5(OH_4)\right) + 6H^+ = 5H_2O + 2Al^{3+} + 2SiO_2$$
$$K - Feldspar\ (KAlSi_3O_8) + 4H^+ = 2H_2O + Al^{3+} + 3SiO_2$$

While geochemical trapping can have a greater impact on carbon dioxide over hundreds or thousands of years, the short-term effects of these trapping mechanisms are relatively small (i.e., not significant), and fluid movement is predominated by hydrodynamic and solubility trapping. Given that, plus the significant computational burden on the model runs created by including geochemical reactions and trapping mechanisms in the GEM simulator, the geochemical processes have not been included in the simulation cases.

#### 2.2.1.7 Trapping Summary

After the containment zone overlying the reservoir, the significant mechanisms by which $CO_2$ is trapped in the storage interval [redacted]

[redacted]

Figure 2-5 – Balance of Injected $CO_2$

### 2.2.2 Structural and Stratigraphic Elements

The model was built using the geologic data described in *Section 1 – Site Characterization*, on how the analysis of well logs, core data, and seismic data were used to generate structure maps and hydrogeology, and to define other rock properties. [redacted]

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Vertical Permeability

Permeability normal to the bedding plane is usually lower than the permeability in the parallel direction. In most cases, "normal to the bedding plane" equates to *vertical* permeability, while the parallel-direction permeability corresponds to *horizontal* permeability. This contrast is caused by vertical heterogeneity over multiple scales, from very small (fractional inch) through many feet in range. By comparison, the scales of heterogeneity in the horizontal orientation will be significantly larger.

[redacted]

[redacted]

### 2.2.3 Relative Permeability and Capillary Pressure

Relative permeability curves were generated using the industry-standard power law model based on the approach developed by Corey (Corey, 1954). In this model, the relative permeability for the respective water and supercritical gas phases are based on the normalized saturation, scaled between the end points of mobility for a respective phase, and raised to an exponent value (termed the "Corey exponent"). Relationships for water and gas relative permeabilities can be expressed with the following equation. The gas relative permeability applies to the supercritical $CO_2$ phase.

$$k_{rw} = k_{rwcg} \left[\frac{(S_w - S_{wc})}{(1 - S_{wc} - S_{gc})}\right]^{nw}$$

And

$$k_{rg} = k_{rgrl} \left[\frac{(S_g - S_{gc})}{(1 - S_{wc} - S_{gc})}\right]^{ng}$$

Where:

$k_{rw}$, $k_{rg}$ = Relative permeability to water and gas phases, respectively

$k_{rwcg}$ = Water relative permeability endpoint, $k_{rw}$ at critical gas saturation

$k_{rgrl}$ = Gas relative permeability endpoint, $k_{rc}$ at irreducible water saturation

$S_w$, $S_g$ = Water and gas saturations, respectively

$S_{wc}$ = Irreducible saturation of water

$S_{gc}$ = Critical saturation of gas

$nw$, $ng$ = Corey exponents for water and gas curves, respectively.

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When considering a relative permeability relationship, it is important to look at the data in the context of reservoir conditions, using in situ fluid properties by the generation of a fractional flow curve. Absent gravity effects, the fractional flow of $CO_2$ vs. saturation is calculated using the relationship:

$$f_g = \frac{1}{1 + \frac{\mu_g}{\mu_w}\frac{k_{rw}}{k_{rg}}}$$

Where $f_g$ represents the volume fraction of the gas (supercritical $CO_2$), $\mu_g$ and $\mu_w$ represent the in situ viscosity for the $CO_2$ and brine, and $k_{rw}$ and $k_{rg}$ represent the relative permeability for the brine and $CO_2$ at the saturations evaluated. [redacted]

[redacted] Buckley & Leverett, 1942) (Welge, 1952). [redacted]

[redacted]

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#### 2.2.3.1 Capillary Pressure Relations

[redacted] Low permeabilities, together with associated high capillary-entry pressures, will combine to prevent flow through the confining interval. [redacted]

[redacted]

### 2.2.4 Initial Conditions

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### 2.2.5 Injection Rate

[redacted]

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### 2.2.6 Injected Fluids Composition

[redacted]

[redacted]

### 2.2.7 Completion Plan

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## 2.3 Model Orientation and Gridding Parameters

### 2.3.1 Spatial Conditions

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### 2.3.2 Boundary Conditions

Boundary Definition

The top and base of the model were set up as no-flow boundaries to vertical flow, these being the upper and lower confining zones, respectively. Each of the lateral edges of the model has been connected to one or more numerical aquifers, using the Fetkovich water-influx calculation option (Fetkovich, 1971), to characterize connections between the modeled area and surrounding region. The use of Fetkovich-type numerical aquifers allows for the definition of aquifers having finite connectivity to the reservoir model. [redacted]

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[redacted] (Leibrock, Hiltz, & and Huzarevich, 1951). [redacted]

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### 2.3.3 Model Time Frame

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## 2.4 $CO_2$ Plume Model Results

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### 2.4.1 Critical Pressure Front

The second component to defining the AOR is determining the extent of the critical pressure front. The worst-case scenario for moving reservoir fluids to the Underground Source of Drinking Water (USDW) would be through either an improperly plugged and abandoned wellbore, or a subsurface feature that is open in the base of the USDW and at the top of the injection interval. This resultant pressure is referred to as the *critical pressure*. The methodology for finding critical pressure was sourced from Environmental Protection Agency (EPA) Method 1 guidance, for calculations based on displacing fluid initially present in the borehole in the hydrostatic case.

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[redacted] McCain, 1991). [redacted]

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## 2.5 Area of Review Delineation

Title 16 of the Texas Administrative Code (TAC) **§5.203(d)(1)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.84(b)**] requires that an AOR be delineated for a Class VI carbon sequestration well application. The EPA defines the AOR as the greater of either the maximum extent of the separate-phase plume (pore occupancy plume), or the pressure front where the pressure buildup is of sufficient magnitude to force fluids from the injection zone into the formation matrix of a USDW. Both parts of this definition were analyzed to define the Orchard #2 AOR.

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## Appendix 2-1 Water Property Correlations

Density of formation water at standard conditions:

$$\rho_w = 62.368 + 0.438603 \times S + 1.60074 \times 10^{-3} \times S^2$$

This correlation has been found to be as accurate as a laboratory measurement, throughout the full range of solids contents. (McCain, 1991)

Correction of formation water density to reservoir conditions $f(p, T)$:

$$\rho_{w(p,T)} = \rho_w / B_w$$

Formation volume factor of water, $B_w$, a function of pressure and temperature:

$$B_w = (1 + \Delta V_{wp})(1 + \Delta V_{wp})$$

These correlations are valid for the full range of potential dissolved solids content at temperatures less than 260°F and pressures less than 5,000 psia. (McCain, 1991)

Change in water volume vs. temperature ($\Delta V_{wT}$):

$$\Delta V_{wT} = -1.0001 \times 10^{-2} + 1.33391 \times 10^{-4} \times T + 5.50654 \times 10^{-7} \times T^2$$

Change in water volume vs. pressure ($\Delta V_{wp}$):

$$\Delta V_{wp} = -1.95301 \times 10^{-9} \times (pT) - 1.72834 \times 10^{-13} \times (p^2T) - 3.58922 \times 10^{-7} \times p - 2.25341 \times 10^{-10} \times p^2$$

Nomenclature:

| | | |
|---|---|---|
| $B_w$ | = | *Water formation volume factor vol/vol* |
| $\rho$ | = | *density, lb/ft³* |
| $S$ | = | *weight percent dissolved solids (equivalent to milligrams per liter* $\times 10^{-4}$ ) |
| $T$ | = | *Temperature, °F* |
| $p$ | = | *Pressure, psia* |

Reference:

McCain, W. (1991). Reservoir-Fluid Property Correlations - State of the Art. *SPE Reservoir Engineering*, 266-272.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

# SECTION 3 – AREA OF REVIEW AND CORRECTIVE ACTION PLAN

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**Figures**

[redacted]

[redacted]

## Tables

[redacted]

## 3.1 Introduction

Title 16 of the Texas Administrative Code (TAC) **§5.203(d)(1)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.84(b)**] requires that an area of review (AOR) be conducted for a Class VI carbon sequestration well application. The Environmental Protection Agency (EPA) defines the AOR as the greater of either the maximum extent of the separate-phase plume (pore occupancy plume), or the pressure front where the pressure buildup is of sufficient magnitude to force fluids from the injection zone into the formation matrix of an Underground Source of Drinking Water (USDW). Both parts of this definition were analyzed for the Orchard [redacted] AOR.

## 3.2 Model Background

Model Name and Version: **GEM 2022.30**

Model Authors/Institution: Computer Modelling Group, Ltd.

Description of model: Equation-of-state (EOS) reservoir simulator for compositional, chemical, and unconventional reservoir modeling.

## 3.3 Model Inputs and Assumptions

The input parameters for the GEM model are summarized in Table 3-1. These parameters are based on the values estimated at the Orchard [redacted] location.

[redacted]

[redacted]

## 3.4 <u>Site Geology and Hydrology</u>

A 3D computational model of the geologic layers from [redacted] was constructed using Schlumberger's Petrel$^{TM}$ software. The results from the site characterization work were used as inputs to create static (*geologic*) and dynamic (*simulation*) models.

### 3.4.1 Surfaces

[redacted]

### 3.4.2 Mesh

The 3D mesh (or grid) was created using the surfaces as inputs. The horizontal (I-J) grid dimensions in the static model are [redacted] Table 3-2 shows the cell count and average thickness for the vertical cells in the static model within the Orchard area. Figure 3-1 shows a map of the static model grid boundary.

[redacted]

[redacted]

[redacted]

[redacted]

### 3.4.3 Property Distribution

Properties (e.g., porosity, permeability) were populated in all cells [redacted] ayers in the 3D static model. [redacted]

#### 3.4.3.1 Facies

The site-characterization results incorporate facies determinations to build the porosity and permeability models [redacted]

#### 3.4.3.2 Porosity

Cross-plot porosity was calculated for wells with both neutron and density well logs. The porosity was upscaled from well logs (resolution approximately 0.25’) to grid cells [redacted] via arithmetic averaging. Figure 3-2 shows a comparison of the well logs and the upscaled porosity values within grid cells for the type well. A normalized score of the porosity data using all the upscaled porosity data was completed prior to distributing porosity among well locations in the grid.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

#### 3.4.3.3 Permeability

Permeability was calculated for each cell with porosity for the injection zone within the 3D static model, by applying [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 3.4.3.4 Water Saturation

Water saturation was initiated in the dynamic simulation model.

[redacted]

[redacted]

## 3.5 Area of Review: Pore Occupancy Plume

The first AOR is related to the $CO_2$ pore occupancy plume and is delineated using computational plume modeling of an injected $CO_2$ stream. Such modeling accounts for the physical and chemical properties of all phases of the injectate and is constructed based on available site characterization, operational, and monitoring data. (*Section 2 – Plume Model* discusses the methodology and process in detail.) The pore occupancy plume is considered and reviewed based on three primary details: *artificial penetrations*, *subsurface features*, and *pore space rights*.

**Artificial penetrations** located within the AOR must be evaluated for proper completions, plugging, and construction materials. These wellbores must be constructed and/or plugged using appropriate materials to support long-term storage of carbon oxides. Most legacy wells in North America, however, were not constructed with the intent of $CO_2$ storage in mind. Thus, most wellbores located within the pore occupancy plume, that penetrate the gross injection zone, would require a corrective action or contingency plan, to ensure that stored gases do not risk escaping containment by way of these penetrations. Any wells that are identified within this AOR but that do not penetrate the gross injection zone would not pose a threat to the containment integrity—and hence would be excluded from any corrective action or contingency plan.

**Subsurface features** identified within the AOR will be assessed for their expected impact to the gross injection zone. Such features could include faults, folds, mapped fractures, steeply dipping formations, and salt diapirs. Should any structural anomalies be discovered, efforts to assess their sealing nature will be conducted. These features can act as either barriers aiding in containing the stored $CO_2$ or, conversely, as conduits moving the $CO_2$ out of the containment zone. [redacted]

**Pore space rights** are critically important when evaluating a project's potential due to the classification of carbon injection wells as *storage* wells rather than *disposal* wells. To mitigate the risk of an uneconomically viable project, operating strategies and reservoir management practices were designed with the utmost care, to maintain control of the resulting subsurface injectate plume extent.

The area determined for pore space rights was used to identify landowners within the $CO_2$ plume area. [redacted]

[redacted]

## 3.6 Area of Review: Pressure Front

A second AOR considers the pressure front created by the injection of fluids into a previously stable reservoir. Both calculation and computational modeling determine this AOR. The pressure buildup that could cause potential fluid migration is determined for either insufficiently plugged and abandoned artificial penetrations, or subsurface features that are found to penetrate the upper confining interval of the gross injection zone.

The worst-case scenario for moving reservoir fluids to the USDW would be through an improperly plugged and abandoned wellbore or subsurface feature that is open both at the base of the USDW and at the top of the injection interval. This resultant pressure is referred to as the *critical pressure*, and the methodology for finding it came from EPA Method 1 guidance for calculations based on displacing fluid initially present in the borehole in the hydrostatic case.

Nearby Texas Railroad Commission (TRRC) Groundwater Advisory Unit (GAU) letters [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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[redacted] [redacted]

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[redacted] [redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted] to ensure adequate protection of the USDW, the pressure front extent was used to define the AOR. Any subsurface features identified within it were assessed for appropriate USDW protection and, if deemed insufficient, included in the corrective action or contingency plan.

[redacted]

[redacted]

## 3.7 Reevaluation of AOR

Per 16 TAC **§5.203(d)(2)(B)** [40 CFR **§146.84(b)(2)**] requirements, Orchard Storage will reevaluate the AORs at each of the following intervals:

- At a minimum frequency of five years
- Upon detection of a significant change in the plume
- As otherwise warranted by routine monitoring or operational conditions

Wells identified as requiring corrective action within the reevaluated AORs will be addressed in an amended AOR and corrective action plan that will be submitted to the EPA Underground

Injection Control (UIC) Director for approval. Once approved, all amendments and corrective plans will be incorporated into the permit and subjected to permit alteration requirements.

If the evaluation does *not* result in changes to the AORs or the corrective action plan, Orchard Storage will demonstrate to the Director that such changes are not needed, by providing the supporting monitoring data and model results. All model inputs and data used in AOR reevaluations will be retained for 10 years.

## 3.8 Operating Strategies Influencing Reservoir Modeling Results

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

These plume extents were digitized from the GEM output and imported into ArcGIS for use as the defined area of influence for establishing the Orchard [redacted] AOR. As discussed in *Section 3.5*, Orchard Storage conducted a review to identify any artificial penetrations or other features that may endanger the lowermost USDW as a result of injection activity or operations per 16 TAC **§5.203(d)(1)(C)** [40 CFR **§146.84(c)(3)**]**.** Orchard Storage also generated maps showing the area of influence and any man-made structures found within the AOR. [redacted]

[redacted]

[redacted]

## 3.9 Area of Review Results

[redacted]

[redacted] o faults or other geologic features or man-made structures were found within the AOR that could affect the integrity of the disposal intervals for permanent $CO_2$ sequestration.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

## 3.10 Corrective Action Plan and Schedule

[redacted] the plume extent AOR considers the pore space occupied by the $CO_2$ plume as determined by the reservoir modeling results. No wells were found to be present within the bounds of the pore space AOR.

The pressure front AOR covers a calculated distance, where the injected $CO_2$ could pressure up the reservoir enough to allow brine and other formation fluids to be pushed upward into a USDW interval. [redacted]

Upon each reevaluation of the AOR, a new review of all artificial penetrations and other geologic structures will be performed and the corrective action plan updated as needed.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

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## 3.11 Area of Review Revaluation Plan and Schedule

### 3.11.1 Proposed Reevaluation Cycle

In accordance with 16 TAC **§5.203(d)(2)(B)(i)** [40 CFR **§146.84(b)(2)(i)**], Orchard Storage will reevaluate the AORs at least every five years or upon a triggering event. Table 3-8 provides a list of these possible triggers and, should one occur, the measures to be taken. The evaluations will be used to validate the plume model against actual, empirical results.

[redacted]

[redacted]

[redacted]

## 3.12 Conclusion

The results of this AOR investigation validate the favorable conditions for carbon sequestration at the proposed Orchard [redacted] area. [redacted] nless otherwise triggered by one of the cases above, the AOR investigation will be reevaluated at least every five years.

[redacted]

[redacted]

[redacted]

# SECTION 4 – ENGINEERING DESIGN AND OPERATING STRATEGY

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### Figures

## Tables

[redacted]

## 4.1 Introduction

This section describes the engineering design details and operational strategies employed during the planning of the proposed [redacted] injection well and associated monitoring wells. The details meet the requirements of Title 16, Texas Administrative Code (TAC) **§5.203(e)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.86**]. Class VI regulations include specific requirements for the design and operation of a carbon capture and storage (CCS) well. This section of the permit application addresses each of those requirements in detail.

## 4.2 Injection Well

### 4.2.1 Engineering Design

A Class VI $CO_2$ sequestration well must be designed to protect any Underground Source of Drinking Water (USDW) from any $CO_2$ injectate contamination. $CO_2$ mixed with formation fluids and other injectate components—a combination producing carbonic acid with a pH as low as 3—is highly corrosive to the metallurgy of many of the well components.

The design parameters for Orchard [redacted] and associated monitoring wells will therefore consider injection rates, volumes, pressures plus fluid properties, chemical properties of the injectate fluid, and estimated total storage volumes in the formation—thereby making the wells designed to withstand the corrosiveness of the injectate. Special metallurgies are considered for the casing, tubing, wellhead equipment, and downhole tools.

The drilling program also includes the types of cement used in the wellbore. The cement design and products used to cement the well will create good bonding between the casing and formations while withstanding the injectate's corrosive nature. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 4.2.2 General Outline of Well Design and Completion Schematic

Orchard [redacted] was designed with the following specifications:

[redacted]

[redacted]

Within 30 days after the completion of Orchard #2, Orchard Storage Company LLC (Orange Storage) will file a complete record of the well with the Underground Injection Control (UIC) Division showing the current completion details, per 16 TAC **§5.206 (c)(2).** [redacted]

### 4.2.3 Detailed Discussion of Injection Well Design

[redacted]

Table 4-1 shows the standard conditions of $CO_2$ used in the modeling and flow calculations.

Table 4-1 – $CO_2$ Standard Conditions

| Temperature °F | Pressure Psia* | Density lbm**/cu ft | Enthalpy Btu/lbm | Entropy Btu/lbm-°R |
|---|---|---|---|---|
| 60 | 14.7 | 0.11666 | 214.18 | 0.64759 |

*Pounds per square inch absolute

**Pound mass

Tubing design sensitivity was run, considering calculated pipe-friction losses, exit velocities, and economic considerations. Detailed reservoir-engineering model runs estimated the bottomhole injection pressures (BHIPs) over time (Figure 4-2). The data in Figure 4-2 not only identifies when the maximum BHIP occurs during project life and the resulting maximum injection pressure at the surface, but also allows for the proper design of the casing, tubing, and wellhead configurations.

[redacted]

[redacted]

Table 4-2 provides the pipeline specifications for the $CO_2$ stream to be injected in Orchard #2.

[redacted]

[redacted]

[redacted]

[redacted] The chemical composition modeled is outlined in Table 4-3.

[redacted]

[redacted]

The results in Table 4-4 were determined from those inputs:

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]e

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

#### 4.2.3.1 Conductor Casing

[redacted]

#### 4.2.3.2 Surface Casing

[redacted] asing will be run and cemented with the casing centered in the open hole using centralizers. Being centralized, the size of the annulus chosen will provide a consistent cement thickness between the casing and the open hole. This will help to ensure a quality cement bond and create two barriers between the USDW formation and wellbore during the remaining drilling operations. Cement will be circulated to the surface, and a top job will be provided, if needed, should the cement level fall after the cement has been circulated to the surface. After cementing, a cement bond log will be run to evaluate and verify good bonding throughout the surface hole. Once the production casing has been run and cemented to the surface, there will be four barriers between the USDW formation and the wellbore.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

#### 4.2.3.3 Production Casing

The production (i.e., long-string) casing is the final, permanently cemented string of casing installed in the well, to be run from the surface to TD then cemented back to the surface. There are several critical design criteria for the long string:

- [redacted]

A detailed metallurgical analysis was performed that considered the chemical composition of the injectate and downhole conditions (Table 4-2, in *Section 4.2.3*) and is included in *Appendix D*. When dry, $CO_2$ is not considered corrosive. The production casing and related accessories will be a [redacted] prevent corrosion and downhole or surface failures, should fluids enter the wellbore and contact the injectate stream. The production casing will be installed using premium connections.

The production casing will be cemented with acid-resistant tail cement from TD to 500’ above the

UCL. This will protect the cement in the annulus from carbonic acid damage and prevent channeling. The cement is intended to maintain good bonding between formation and casing to preserve integrity and maximize the well's life. The annular section from the top of the UCL to surface will be cemented with a Type I/II salt saturated cement (Figure 4-1, in *Section 4.2.1*).

The engineering and design parameters for the production casing are summarized in the following tables (4-8 through 4-10):

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

4[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

#### 4.2.3.6 Injection Tubing

The injection tubing size was selected based on the injection volumes, rates, and injectate composition. The injectate composition and the potential for a corrosive environment were considered when determining the metallurgy of the tubing as it was for the casing string. Although the injectate stream is anticipated to be dry and noncorrosive, the planned design allows for a surface upset or invasion of connate water from the reservoir. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

4.2.3.8 Wellhead Discussion

The wellhead is designed to accommodate anticipated working pressures and eliminate corrosion complications. The wellhead equipment will be manufactured from a combination of stainless-steel components across the hanger and casing spool. Inconel lining will be placed across trims, stems, gates, valves, etc. The final pressure rating will be confirmed before beginning the manufacturing process. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

4.2.4.3 Formation Fluid Testing

Before setting the production casing string, samples of the formation fluid will be obtained by running an open-hole fluid recovery tool. Recovery sections will be determined based on open-hole evaluations. Multiple samples will be taken per section based upon results of the open-hole logs. Data collected during testing and logging will include formation fluid temperature, pH, conductivity, reservoir pressure and static fluid level. Additionally, drawdown and buildup tests, as described in *Section 5 – Testing and Monitoring Plan*, will be performed to further quantify reservoir properties.

4.2.4.4 Step-Rate Test

After the initial injection interval is perforated, a step-rate test will be performed prior to any stimulation work, as discussed in *Section 5*. The purpose of this test is to quantify the injectivity potential and the fracture pressure of the injection zone.

[redacted]

[redacted]

### 4.2.6 Injection Well Operating Strategy

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Surface and bottomhole injection pressures will be continuously monitored during injection, with surface injection rates and pressures adjusted as necessary, to ensure that bottomhole pressures remain below maximum pressure limits. The maximum injection pressure limits will be [redacted]

The operating strategy for Orchard [redacted] is as follows:

- The gross injection interval will be perforated at the initial completion.
- The injectate fluids will be injected throughout the entire injection interval.
- Plume migration surveys will be conducted every five years to contrast actual plume development with the simulated plume model as discussed in *Section 5 – Testing and Monitoring Plan.*
- The wellbore will have continual monitoring of bottomhole pressures and temperatures throughout the life of the well.

### 4.2.7 Injection Well Operational Summary

Orchard [redacted] is designed to maximize the available pore space and safely sequester $CO_2$. Formation pressures and temperatures will be measured within the wellbore and used to update the plume model and refine future injection strategies, as discussed in *Section 5*. This process will provide accurate evaluation and assurance of where the $CO_2$ is moving and at what rate, allowing for alteration to the injection and operation strategy if required. After injection ceases, the well will be plugged as discussed in *Section 6 – Injection Well Plugging Plan*.

## 4.3 Above Confining Zone Monitoring Wells

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Once the conductor pipe is established, the inner portions can be flushed out and evacuated, and drilling can commence.

4.3.1.2 Surface Casing

The surface hole will be drilled with a 12-1/4" bit with casing set below the USDW. [redacted] with the casing centered in the open hole using centralizers. Being centralized, the size of the annulus chosen will provide a consistent cement thickness between the casing and the open hole. This will help to ensure a quality cement bond and create two barriers between the USDW formation and wellbore during the remaining drilling operations. Cement will be circulated to the surface, and a top job will be provided, if needed, should the cement level fall after the cement has been circulated to the surface. After cementing, a cement bond log will be run to evaluate and verify good bonding throughout the surface hole. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

#### 4.3.1.3 Production Casing

The production (i.e., long-string) casing is the final, permanently cemented string of casing installed in the well, to be run from the surface to TD then cemented back to the surface. As this well does not penetrate the UCL, acid-resistant cements and tubulars were not considered.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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4.3.1.7 Wellhead Discussion

The wellheads are designed to accommodate anticipated working pressure. The final pressure rating will be confirmed before beginning the manufacturing process. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 4.3.3 Overview of Well Completion Program

After setting and cementing the production casing, the production tubing string will be run. The completion program includes the following:

- Make bit and scraper run to TD.
- Run cased hole logs as described in Table 4-21 (in *Section 4.3.1.3*).
- Test the casing.
- [redacted]
- Displace the hole with corrosion-resistant packer fluid.
- Run tubing and packer to depth, set and test the same.

## [redacted] Monitoring Well

[redacted]

### 4.4.1 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 4.4.2 Monitoring Well Operational Strategy Summary

[redacted]

The location for this project is ideally situated for carbon sequestration monitoring purposes. Combining the best engineering practices in the design of the well with a state-of-the-art monitoring system and robust reservoir management strategy, this monitoring well will help to safely store $CO_2$ for years to come.

[redacted]

[redacted]

- [redacted]

[redacted]-

[redacted]

# SECTION 5 – TESTING AND MONITORING PLAN

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**Figures**

[redacted]

## Tables

[redacted]

## 5.1 Introduction

The operating plans for the proposed Orchard Storage Company LLC (Orchard Storage) Orchard [redacted] injection well include robust testing and monitoring programs, which are designed to satisfy the requirements of 16 Texas Administrative Code (TAC) ***§*5.203 (j)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.90**]. This section discusses the key details of this program.

## 5.2 Reporting Requirements

In compliance with 16 TAC **§5.207** [40 CFR **§146.91**] requirements, Orchard Storage will provide the following routine reports to the Underground Injection Control (UIC) Director.

**Per-Occurrence Reporting**:

- Any noncompliance with a permit condition or malfunction of the injection system that may cause fluid migration into or between Underground Sources of Drinking Water (USDWs)
  - Verbal Notification – Reported within 24 hours of the event
- Any evidence that the injected $CO_2$ stream or associated pressure front may cause an endangerment to a USDW
  - Verbal Notification – Reported within 24 hours of the event
  - Written Notification – Reported within five working days of the event
- Any failure to maintain mechanical integrity
  - Verbal Notification – Reported within 24 hours of the event
- Any significant data that indicate the presence of leaks in the well or lack of confinement to the storage reservoir
  - Verbal Notification – Reported within 24 hours of the event
  - Written Notification – Reported within five working days of the event
- Any changes to the physical, chemical, or other relevant characteristics of the $CO_2$ stream from what has been described in the proposed operating data
  - Written Notification – Reported within 72 hours of composition change
- Description of any event that exceeds operating parameters for either annulus pressure or injection pressure, as specified in the permit
  - Verbal Notification – Reported within 24 hours of the event
  - Written Notification – Reported within 72 hours of the event
- Description of any event that triggers a shutoff device, either downhole or at the surface, and the response taken
  - Verbal Notification – Reported within 24 hours of the event
  - Written Notification – Reported within 72 hours of the event
- Any release of $CO_2$ into the atmosphere or biosphere
  - Verbal Notification – Reported within 24 hours of the event

**Semiannual Reports**:

- Summary of wellhead pressure monitoring
- Any changes to the source of the $CO_2$ stream
- Any changes to the physical, chemical, or other relevant characteristics of the $CO_2$ stream from what has been described in the proposed operating data
- Monthly average, plus maximum and minimum values, of injection pressure, flow rate, temperature, volume, and annular pressure
- Description of any event that exceeds operating parameters for either annulus pressure or injection pressure, as specified in the permit
- Monthly volume and/or mass of the $CO_2$ stream injected over the reporting period, and the volume injected cumulatively over the life of the project
- Monthly volume of annulus fluid added
- Results of any monitoring as described in this section

**Annual Reports**:

- Any corrective action performed
- Recalculated area of review (AOR), or statement confirming that the monitoring and operational data supports the current delineation of the AOR on file with the Texas Railroad Commission (TRRC)
- Proof of good faith claim to sufficient property rights for the storage facility operation
- Tons of $CO_2$ injected

**Reports to be submitted within 30 days after the following events**:

- Any well workover
- Any test of the injection well conducted, if required by the Director
- Any periodic mechanical integrity tests (MITs)

**Notification in writing to the UIC authority (16 TAC §5.206(c)), 30 days in advance of**:

- Any planned workover
- Any planned stimulation activities
- Any other planned test of the injection well

Orchard Storage will submit all reports, submittals, and notifications to the Environmental Protection Agency (EPA) and TRRC and ensure that all records are retained throughout the project's life. Per 16 TAC **§5.207(e)** [40 CFR **§146.91(f)**], these records will be maintained for 10 years after site closure—and, after the retention period, delivered to the Director upon request. Monitoring data will be retained for 10 years post-collection, while well-plugging reports, post-injection site care data, and the site closure report will also be retained for 10 years after site closure.

## 5.3 Testing Plan Review and Updates

Per 16 TAC **§5.207(a)(3)** [40 CFR **§146.90(j)**], the Testing and Monitoring Plan will be reviewed and revised, as necessary, at least every five years—to incorporate collected monitoring data. Plan amendments will also be submitted within one year of an AOR reevaluation following significant facility changes, such as the development of offset monitoring wells or newly permitted injection wells within the AOR, or as required by the Director.

## 5.4 Testing Strategies

### 5.4.1 Open Hole Logging

Orchard Storage plans to run an advanced suite of open hole logs to obtain data for parameters used in static and dynamic subsurface modeling. The Baker Technology log descriptions provided below simply exemplify the types of logs to be run; the specific logging vendor will be selected just prior to drilling the well, as commercial and supply chain issues may affect the final vendor selection.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 5.4.2 Initial Step-Rate Injectivity Test

Before beginning $CO_2$ injection, Orchard Storage will conduct a step-rate injectivity test to measure the fracture gradient of [redacted] in compliance with 16 TAC **§5.203(f)(2)(A)** [40 CFR **§146.87(d)(1)**] and 16 TAC **§5.203(f)(2)(C)** [40 CFR **§146.87(e)(3)**]. Bottomhole, surface readout pressure, and temperature gauges will be run to the total depth of the wellbore, with the initial bottomhole pressure and temperature readings measured before injection. All gauges will be calibrated before testing.

5.4.2.1 Testing Method

Specific wellbore and injection zone properties will define the final test parameters. The following test method outlines the expected test injection rates and times. The injection of brine will begin at 1.5 barrels per minute (bpm) and be held for a minimum of 30 minutes. The injection rates will be stepped up in 2.0–3.0 bpm increments until at least three measurements have been taken, both below and above the estimated formation-fracture initiation pressure. Each stage will require a hold duration of at least 30 minutes—or until the pressure has stabilized.

A plot of stabilized injection *pressure* versus injection *rate* at each step should graphically represent a linearly sloped line, until the fracture initiation pressure has been exceeded. Table 5-1 shows a step-rate test example, and Figure 5-1 is the corresponding graphical representation.

Table 5-1 – Step-Rate Injectivity Test Example

| Step | Rate (bpm) | Time (min) | Pressure (psi) |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 0.2 | 30 | 100 |
| 2 | 0.4 | 30 | 200 |
| 3 | 0.8 | 30 | 400 |
| 4 | 1.6 | 30 | 802 |
| 5 | 2.4 | 30 | 1,201 |
| 6 | 3.2 | 30 | 1,400 |
| 7 | 4.0 | 30 | 1,600 |

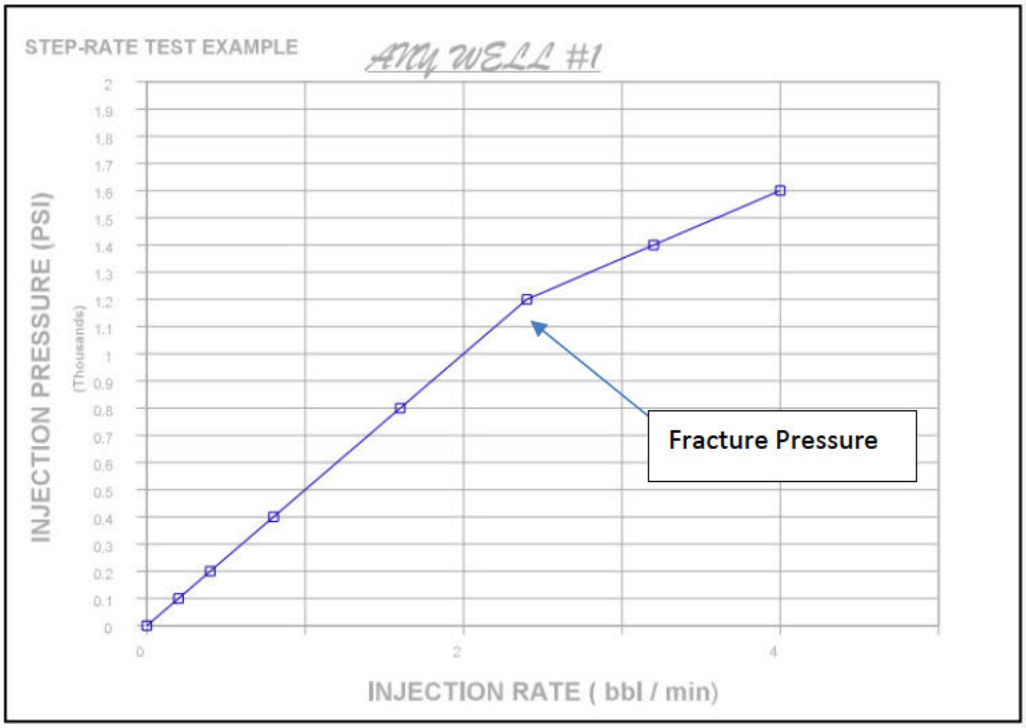


Figure 5-1 – Example of a Step-Rate Injectivity Test[1]

Upon reaching a stabilized pressure after completing the final step, pressures will be recorded at the highest frequency of the gauge, for a period indicated by the step-up phase of testing, to calculate the rate of pressure bleed-off.

[1] https://www.epa.gov/sites/default/files/documents/INFO-StepRateTest.pdf

### 5.4.3 Chemical Composition Confirmation Testing

In compliance with 16 TAC **§5.203(j)(2)(A)** [40 CFR **§146.90(a)**] requirements, Orchard Storage will sample the $CO_2$ injection stream and evaluate any potential interactions of carbon dioxide and other injectate components. $CO_2$ injection stream samples will be taken quarterly for chemical analysis of the parameters listed in Table 5-2, plus continuous pressure and temperature analysis.

#### 5.4.3.1 Sampling Methods

[redacted] Sampling cylinders will be purged with the injectate gas to expel laboratory-added gas.

[redacted]

### 5.4.4 Mechanical Integrity Testing – Annulus Pressure Test

In accordance with 16 TAC **§5.203 (h)(1)(C)** [40 CFR **§146.89(b)**], Orchard Storage will demonstrate mechanical integrity by performing annular pressure tests when the well is completed, before the start of injection, and after any workover operation involving the removal and replacement of the tubing and packer.

The annular pressure tests should demonstrate the mechanical integrity of the casing, tubing, and packer. These tests are conducted by pressuring the annulus to a minimum of 500 pounds per square inch (psi) fluid pressure, then using a block valve to isolate the test pressure source from the test pressure gauge upon test initiation—with all ports into the casing annulus closed except the one monitored by the test pressure gauge. The test pressure will be monitored and recorded for a minimum duration of 30 minutes using a pressure gauge, with sensitivities that can indicate a loss of 5%. Any loss of test pressure exceeding 5% during the minimum 30 minutes will indicate a lack of mechanical integrity.

All annulus pressure test results will be submitted to the TRRC on Form H-5 within 30 days of completing the log run.

### 5.4.5 External Mechanical Integrity Testing – [redacted]

[redacted]

[redacted]

### 5.4.6 Pressure Fall-Off Testing

Orchard Storage will perform a required pressure falloff test every five years per 16 TAC **§5.203 (j)(2)(F)** [40 CFR **§146.90(f)**]. The tests will measure near-wellbore formation properties and monitor for near-wellbore environmental changes that may impact injectivity and result in pressure increases.

#### 5.4.6.1 <u>Testing Method</u>

Injection rates and pressures will be held as constant as is practical prior to the test. Pressure and rate data will be recorded continuously before and during the falloff period. Pressure gauges to supplement the permanent gauges will be run into the well, if needed, several days prior to initiation of the falloff test—to allow for a period of stable injection prior to shut-in. The length of time for stabilization prior to shut-in will be determined in advance, using pressure-transient well-test design methods that incorporate anticipated rates and formation properties.

Ideally, the falloff test will be run sufficiently long to allow identification and analysis of the Infinite Acting Flow Regime (IARF). Given the heterogeneous nature of the injection interval, it may not be possible to identify this IARF through simple, semi-log straight-line plots. [redacted]

5.4.6.2 Analytical Methods

Mechanical integrity will be determined through standard diagnostic plotting. This determination is accomplished via analysis of observed pressure changes and pressure derivatives on standard diagnostic log-log and semi-log plots, using specialized pressure-transient analysis software. The analysis will integrate additional data beyond the injection well's rate and pressure data. The additional data may include operational history, offset wells' injection and operational history, and distributed temperature sensing (DTS) sensor data from the injection well being tested. Depending on the complexity of the pressure response, it may be necessary to incorporate numerical modeling into the interpretation workflow.

Comparing pressure falloff tests can expose significant changes in the well or reservoir conditions before initial injection with later tests. The effects of the fluid flow as well as the injected fluid's compressibility will be considered and incorporated into the analysis. The well parameters resulting from falloff testing will be compared against those used in AOR determination and computational site modeling. Notable changes in reservoir properties may dictate that an AOR reevaluation is necessary.

5.4.6.3 Quality Assurance/Control

All field equipment will undergo inspection and testing before operation. Manufacturer calibration recommendations will be adhered to during the pressure gauge use in the falloff test. Documentation certifying proper calibration will also be enclosed with the test results. Further validation of the test results will be recorded using a second bottomhole pressure gauge.

### 5.4.7 Injection Conformance Monitoring

[redacted] If the rate changes at a specific set of perforations, this data can be used, along with other pressure and rate information, to gain valuable insight into injection conformance. The use of this data will allow changes to operating or completion parameters as necessary for storage-zone management purposes.

Per 16 TAC **§5.206 (d)(2)(F)(i)** [40 CFR **§146.88(e)(2)**], automatic shut-off systems and alarms will be installed to alert the operator and shut in the well when operating parameters such as annulus pressure, injection rate, etc., diverge from permitted ranges or gradients.

### 5.4.8 Cement Evaluation and Casing Inspection Logs

Per 16 TAC **§5.203 (h)(2)** [40 CFR **§146.89(d)**], a comprehensive cased-hole logging suite will be run on the production casing string at the time of initial well completion. This suite of logs will include a radial cement investigation, a multi-arm caliper, and a digital log, to establish the condition of the casing metal. This survey will characterize the original state of the wellbore materials. Following the tubing and packer installation, an initial through-tubing inspection log will be run on the well. This survey will serve as the baseline for future casing-inspection efforts.

[redacted]

Orchard Storage will provide a schedule of all logging plans to the Director at least 30 days prior to conducting the first test. Notice will be provided at least 48 hours in advance of such activity.

#### 5.4.8.1 Casing Log Equipment Overview

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 5.4.9 Logging and Testing Reporting

A report that includes log and test results obtained during the drilling and construction of Orchard #2, and interpreted by a knowledgeable log analyst, will be submitted to the Director as per 16 TAC **5.203 (h)(2)** [40 CFR **§146.87(a)**].

## 5.5 <u>Monitoring Programs</u>

### 5.5.1 Continuous Injection Stream Monitoring

Orchard Storage will continuously monitor the injection pressures, rates and volumes, and annulus pressures to meet the 16 TAC ***§*5.203 (j)(2)(B)** [40 CFR **§146.90(b)**] requirements. [redacted] Per 16 TAC ***§*5.206 (d)(2)(B)**, the total volume of $CO_2$ injected into the Orchard Project facility will be metered through either a master meter or a series of master meters. The volume or mass of $CO_2$ injected into [redacted] will be metered through an individual well meter.

[redacted]

[redacted]

[redacted]

[redacted]

5.5.1.1 Analytical Methods

Orchard Storage will review and interpret continuously monitored parameters to validate that they are within permitted limits. The data review will include trends, to help determine any need for equipment maintenance or calibration. These data reports will be submitted semiannually.

### 5.5.2 Corrosion Coupon Monitoring

Orchard Storage will monitor for corrosion of the well tubing and casing materials per the 16 TAC ***§*5.203 (j)(2)(C)** [40 CFR ***§*146.90(c)**] requirements, employing a corrosion coupon monitoring system for this evaluation. [redacted]

5.5.2.1 Sampling Methods

Corrosion coupons, comprised of the same material as the injection flowline, tubing, and production casing, will be placed in the $CO_2$ injection flowline. These coupons will be removed quarterly and examined for corrosion per American Society for Testing and Materials (ASTM) standards for corrosion-testing evaluation. After removal, the coupons will be visually inspected for signs of corrosion, including pitting, and measured for weight and size. The corrosion rate will be estimated by applying a weight-loss calculation method that divides the weight loss, recorded during the exposure period, by the duration of that period.

### 5.5.3 Soil Gas Monitoring

Soil gas monitoring will be used to check chemical compositions of the near-surface environment and soil vadose zone. These environments are subjected to strong seasonal effects and influenced by a wide range of natural process and human activities. As with any of these types of monitoring, establishing a baseline condition is very important. Orchard Storage intends to install the soil gas monitoring stations at least one year prior to injection, to better understand baseline conditions through multiple seasons. [redacted] uality assurance and traceability methods will be used to ensure proper handling of samples and lab techniques.

### 5.5.4 Ground Water Quality Monitoring

To meet 16 TAC **§5.203 (j)(2)(C)** [40 CFR **§146.90(d)**] requirements, groundwater quality and geomechanical monitoring will be conducted above the confining zone to detect potential changes that could result from fluid leakage from the injection zone. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

#### 5.5.4.2 Analytical Methods

Orchard Storage will test water samples and maintain results for the parameters that were listed in Table 5-4. If the $CO_2$ injectate contains unique impurities, then groundwater samples will also be tested to flag any concentrations of these impurities exceeding the baseline. Testing results will be stored in an electronic database.

Potential signs that fluid may be leaking from the injection interval(s) may be detected upon observation of the following trends:

- Change in TDS
- Changing signature of major cations and anions
- Decreasing pH
- Increasing concentration of injectate impurities
- Increased concentration of leached constituents
- Increased reservoir pressure and/or static water levels

If a significant change is observed, further investigation may be warranted. These next steps could include, but not be limited to, using a pressure jar to collect a sample of the fluid and dissolved $CO_2$.

#### 5.5.4.3 Laboratory to Be Used/Chain of Custody Procedures

[redacted]

Orchard Storage will observe standard chain-of-custody procedures and maintain records, to allow full reconstruction of the sampling procedure, storage, and transportation, including problems encountered.

[redacted]

5.5.4.5 <u>Plan for Guaranteeing Access to All Monitoring Locations</u>

The installation of groundwater monitoring wells is part of the surface-use lease agreements with the landowners across the plume area, ensuring access to the well locations for sampling and maintenance purposes. Unauthorized access will be prevented by capping and locking out the well.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

### 5.5.7 Injection Plume Monitoring

Orchard Storage will use both direct and indirect methods to track the $CO_2$ plume and the pressure front tracking, in accordance with 16 TAC **§5.203 (j)(2)(E)** [40 CFR **§146.90(g)**]. The critical pressure front will be directly monitored by using continuously recorded pressures and temperatures to calculate the extent of this pressure increase. [redacted]

Orchard Storage will use these methods to verify reservoir conditions during injection, track plume and critical pressure front migration, and validate the reservoir model. Continuous pressure and temperature monitoring of the injection reservoir will allow for monitoring of reservoir conditions and inform calculations, while VSP surveys will determine the actual $CO_2$ plume migration. [redacted]

5.5.7.1 Direct Monitoring: Rate Transient Analysis

Rate transient analysis, in conjunction with reservoir simulations using known reservoir characteristics, will allow for calculating more complex parameters within the injection interval. Direct monitoring will be based on continuous pressure, temperature, and injection rate data to calculate the properties of the reservoir and verify the plume model results.

The reservoir model built during the site evaluation phase will be used to predictively monitor the reservoir conditions during injection operations. Through flow simulation and transient flow analyses, the reservoir model will be updated with injection activity regularly, to evaluate the injection stream's effect on reservoir conditions. This analysis can be performed to monitor the magnitude and extent of temperature and pressure changes within the injection zone. Continual monitoring of bottomhole pressures and temperatures, combined with known reservoir parameters, will be used to calculate reservoir conditions throughout the injection intervals.

Additionally, any shut-in periods can be observed and treated as a pressure falloff test. To do this, the shut-in wellhead pressure, bottomhole pressure, and temperature readings will be recorded and used for pressure-transient analysis of the reservoir. The analysis results will include the radius and magnitude of pressure buildup and reservoir performance characteristics such as permeability and transmissibility. Analysis results will then confirm, and adjust as necessary, the previous model realizations.

[redacted]

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## 5.6 Conclusion

The testing and monitoring plans developed for Orchard [redacted] are designed to acquire essential data to support static and dynamic reservoir modeling, track the growth of the $CO_2$ plume, and ensure that $CO_2$ does not reach USDWs or pose a risk to health, safety, or the environment.

A larger scale map of the monitoring wells plus specification sheets for the planned technologies are provided in *Appendix E*.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

# SECTION 6 – INJECTION WELL PLUGGING PLAN

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## 6.1 Injection Well Plugging Plan and Regulatory Requirements

As described in *Section 4 – Engineering Design and Operating Strategy*, Orchard [redacted] will be completed as a single injection interval [redacted] After the conclusion of [redacted] injection operations, the well will be permanently plugged. Complete plugging and abandonment prognoses are included [redacted]

The following outline describes the procedures and types of plugs that will be set to isolate the injection interval, to prevent contamination of the Underground Sources of Drinking Water (USDWs), and to properly plug and abandon Orchard [redacted] according to Title 16, Texas Administrative Code (16 TAC) **§5.203** and 16 TAC **§3.14** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.92**] regulations.

### 6.1.1 Wellbore Profile Prior to Plugging and Abandonment

Figure 6-1 shows the original wellbore schematic for Orchard [redacted] prior to beginning plugging operations.

[redacted]

[redacted]

### 6.1.2 Pre-Plugging Activities

1. Orchard Storage will comply with all reporting and notification provisions.
   a. The Environmental Protection Agency (EPA) Underground Injection Control (UIC) Director will be notified 60 days in advance of planned plugging efforts [40 CFR ***§*146.92(c)**].
   b. The Texas Railroad Commission (TRRC) and the UIC Director will be notified at least 60 days before plugging a well. If any changes are proposed to the original well-plugging plan, a revised plan will be submitted [16 TAC ***§*5.201(k)(3)(A)**].
   c. A notice of intention to plug and abandon (Form W-3A) will be filed with the appropriate TRRC district office and the UIC Director at least five days prior to the beginning of plugging operations.
   d. Plugging operations will not start until the Director approves the proposed procedure.
   e. The district office will be notified at least four hours before commencing plugging operations.
2. Casing inspection and cement bond logs will be run prior to plugging.
3. Bottomhole reservoir pressure will be measured [redacted] *ection 5 – Testing and Monitoring Plan* (16 TAC **§5.203 (h)(1)(C)** [40 CFR **§146.89(b)**]).
4. External mechanical integrity will be demonstrated through approved temperature logging methods as described in *Section 5*, per 16 TAC **§5.203 (h)(1)(D)** [40 CFR **§146.89(c)**].
5. Orchard [redacted] will be flushed with a buffer fluid prior to pulling the injection tubing and packer (16 TAC **§5.203** and **§3.14** [40 CFR **§146.92(a)**]).
6. All uncemented, non-permanent components of the well will be removed as listed in Table 6-1.

[redacted]

### 6.1.3 Plugging Activities

1. Pull seal assembly from the packer to just above the packer.
2. Fill the wellbore with at least 9.5 pounds per gallon (ppg) of 40 viscosity-treated drilling mud, and ensure the well is in static condition.
3. Pull tubing and seal assembly and remove from the well.
4. Isolate the gross injection interval:
   a. [redacted]

b. [redacted]
c. Displace the cement with at least 9.5 ppg of 40 viscosity-treated drilling mud.
d. The plug will be qualified by tagging the top and conducting a successful pressure test.

5. [redacted] Displace cement with at least 9.5 ppg of 40 viscosity-treated drilling mud.
6. Set a 50’ cement plug from 50’ to the surface.
7. Cut casing 3’ below ground level and weld on a ½” steel plate.

Within 60 days after plugging, Orchard Storage will submit, pursuant to 40 CFR **§146.91(e)**, a certified well-plugging report to the Director. The report will be retained for 10 years following site closure. Also note that a complete well-plugging record (Form W-3), pursuant to 16 TAC **§5.203**, will be filed within **30 days** to the appropriate TRRC district office after plugging operations are completed.

### 6.1.4 Plug Details

Table 6-2 shows the planned plugging details for Orchard #2. Figure 6-2 shows a schematic of Orchard #2 after the well is plugged.

[redacted]

[redacted]

## 6.2 Monitoring Well Plugging Plan and Regulatory Requirements

As described in *Section 4 – Engineering Design and Operating Strategy*, Orchard [redacted] At the conclusion of the post-injection site care period, the well will be permanently plugged. Complete plugging and abandonment prognoses are in *Appendix G*.

The following outline describes the procedures and types of plugs that will be set to isolate the perforated interval and to prevent contamination of the USDWs. Orchard [redacted] will be properly plugged and abandoned according to 16 TAC **§5.203** and **§3.14** [40 CFR **§146.92**] regulations.

[redacted]

#### *6.2.1.1 Monitoring Wellbore Profile Prior to Plugging and Abandonment* [redacted]

The original wellbore schematic for Orchard [redacted] prior to beginning plugging operations, is provided in Figure 6-3.

[redacted]

[redacted]

#### 6.2.1.2 ***Monitoring Well Pre-Plugging Activities, Orchard MW #1***

1. Orchard Storage will comply with all reporting and notification provisions.
    a. The UIC Director will be notified 60 days in advance of planned plugging efforts [40 CFR **§146.92(c)**].
    b. The TRRC and the UIC Director will be notified at least 60 days before plugging a well. If any changes are proposed to the original well-plugging plan, a revised plan will be submitted [16 TAC **§5.201(k)(3)(A)**].
    c. A notice of intention to plug and abandon (Form W-3A) will be filed with the appropriate TRRC district office and the UIC Director at least five days prior to the beginning of plugging operations.
    d. Plugging operations will not start until the proposed procedure has been approved by the Director.
    e. The district office will be notified at least four hours before commencing plugging operations.
2. Casing inspection and cement bond logs will be run prior to plugging.
3. External mechanical integrity will be demonstrated through approved temperature logging methods as described in *Section 5 – Testing and Monitoring Plan*, per 16 TAC **§5.203 (h)(1)(D)** [40 CFR **§146.89(c)**].
4. Orchard [redacted] will be flushed with a buffer fluid prior to pulling the injection tubing and packer seal assembly (16 TAC **§5.203** and **§3.14** [40 CFR **§146.92(a)**]).
5. All uncemented, non-permanent components of the well will be removed as listed in Table 6-3.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Within **60 days** after plugging, Orchard Storage will submit, pursuant to [40 CFR **§146.91(e)**], a certified plugging report to the Director. The well-plugging report will be retained for 10 years following site closure. Also note that a complete well-plugging record (Form W-3), pursuant to 16 TAC **§5.203**, will be filed within **30 days** to the appropriate TRRC district office after plugging operations are completed.

[redacted]

[redacted]

[redacted]

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# SECTION 7 – POST-INJECTION SITE CARE AND SITE CLOSURE PLAN

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## 7.1. Overview

This Post-Injection Site Care (PISC) and Site Closure Plan is prepared to meet the requirements of 16 Texas Administrative Code (TAC) **§5.206(k)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.93**]. This section provides a comprehensive overview of (1) the anticipated plume and pressure front behavior at the end of the injection phase, (2) post-injection monitoring plans, (3) a discussion demonstrating non-endangerment to the Underground Source of Drinking Water (USDW), and (4) site closure plans. This plan provides the activities that Orchard Storage Company LLC (Orchard Storage) will perform once injection has ceased. The program will conclude with the site closure activities, once it is demonstrated that no additional monitoring is needed to ensure that this project does not endanger the USDW. This plan will be maintained during the life of the project and reevaluated every five years and submitted to the Director.

[redacted]

To meet the requirements of 16 TAC **§5.203(m)(2)** [40 CFR **§146.93(a)(2)**], Figure 7-1 and Table 7-1 show the expected pressure differentials in the injection zone, as determined by the plume model described in *Section 2 – Plume Model*.

[redacted]

[redacted]

[redacted]

## 7.3. $CO_2$ Plume Position and Pressure Front at End of Injection and at Closure

To meet the requirements of 16 TAC **§5.203(m)(3)** [40 CFR **§146.93(a)(2)**], Figure 7-2 shows the predicted position of the carbon dioxide plume and associated pressure front at site closure. Figures 7-3 and 7-4 present the cross-sectional views of the stabilized plume at the end of injection and at the time of site closure.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

## 7.4. Post-Injection Monitoring Plan

As required by 16 TAC **§5.206(k)(2)** [40 CFR **§146.93(b)**], Orchard Storage will continue to monitor the site until the project no longer poses an endangerment to USDWs.

### 7.4.1. Post-Injection Monitoring Activities

Post-injection monitoring will be utilized to track the movement of the plume and pressure front per 16 TAC **§5.206 (k)(2)** [40 CFR **§146.93(b)**]. The Testing and Monitoring Plan will be extended and used to confirm not only that the injection project is continuing to conform to the permit conditions, but also that any unexpected USDW endangerment is identified and mitigated. Testing and monitoring activities, as described in *Section 5 – Testing and Monitoring Plan*, will be performed and reported at the frequency shown in Table 7-2.

[redacted]

All testing and monitoring activities listed will be performed and analyzed as discussed in *Section 5*, including quality assurance/quality control measures.

### 7.4.2. Demonstration of Non-Endangerment of USDW

Before the approval of the site closure authorization, Orchard Storage will provide documentation that the USDW is not at risk of endangerment from the $CO_2$ plume, as required by 16 TAC **§5.206(k)(3)** [40 CFR **§146.93(c)**]. Orchard Storage will submit a report to the Underground Injection Control (UIC) Director demonstrating the non-endangerment of the USDW, including site-specific conditions, updated plume model, predicted pressure decline within the injection zone, and any updates to the underlying geological assumptions used in the original model.

## 7.5. Site Closure Plan

Orchard Storage will perform site closure activities to meet the requirements of 16 TAC **§5.203(m)(3)** [40 CFR **§146.93(e)**]. These activities include removing surface equipment, plugging all wells, site restoration, and submission of final site-closure reports.

### 7.5.1. Pre-closure

Notice of intent to close the site will be submitted to the UIC Director at least 120 days before closing operations, per 16 TAC **§5.206(k)(4)** [40 CFR **§146.93(d)**]. If any changes have been made to the original PISC and Site Closure Plan, a revised plan must also be submitted. Relevant notifications and applications, such as plugging requests, must be submitted to and approved by the Texas

Railroad Commission (TRRC) before commencing such activities. No facility closure activities will be executed until the UIC Director has authorized closure.

### 7.5.2. Plugging Activities

Orchard [redacted] and the related monitoring well [redacted] will be plugged as discussed in *Section 6 – Injection Well Plugging Plan*. The plugging and abandonment procedures are designed to prevent the migration of $CO_2$ or formation fluids from the injection interval to the USDW. Before the wells are plugged, their mechanical integrity will be determined by an annulus pressure test, casing inspection log, and temperature log as described in *Section 5 – Testing and Monitoring Plan*. Plugging schematics and procedures are provided [redacted]

### 7.5.3. Site Restoration

Once the injection and monitoring wells are plugged and capped below grade, all surface equipment will be decommissioned and removed from the site. The sites will be restored as agreed with the surface owners.

### 7.5.4. Documentation of Site Closure

Within 90 days of site closure, a final report must be submitted to the Director, per 16 TAC **§5.206 (k)(6)** [40 CFR **§146.93(f)**], and include the following:

- Documentation of appropriate injection and monitoring well plugging, including a copy of the survey plats
- Documentation of well-plugging report
- Records of the nature, composition, and volume of the $CO_2$ stream over the injection period

A record of notation in the facility property deed will be added to provide, in perpetuity, any potential purchaser of the property with

- a complete legal description of the affected party;
- the fact that the land was used to sequester $CO_2$;
- confirmation that the survey plat has been filed with the TRRC/Environmental Protection Agency (EPA);
- the address of the office of the EPA, to which the operator sent a copy of the survey plat; and
- the total volume of fluid injected, the injection zones into which it was injected, and the period over which the injection occurred.

Orchard Storage will retain all records collected during the PISC period for 10 years following site closure. At the end of the retention period, Orchard Storage will deliver all records to the Director, which will thereafter be retained at a location designated by the Director for that purpose.

# SECTION 8 – EMERGENCY AND REMEDIAL RESPONSE PLAN

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**Figure**



**Tables**

## 8.1 Emergency and Remedial Response Plan Overview

This Emergency and Remedial Response Plan for the proposed Orchard #2 Class VI injection well (Orchard Project) was prepared to meet the requirements of 16 Texas Administrative Code (TAC) **§5.206(h)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.94**]. This section is organized into six distinct parts. The parts address the issues of (1) potentially affected infrastructure and parties, (2) definitions of degrees of severity, (3) specific events and their response plans, (4) training, (5) communications plans and notification procedures, and (6) review and updates to this plan. These sections aim to ensure an expeditious, appropriate response to protect any Underground Sources of Drinking Water (USDWs) and maximize the protection of the environment, surrounding community, and company property. This plan will remain in place during the construction, operation, closure, and post-closure periods of the Orchard Project.

## 8.2 Resources/Infrastructure in the AOR

[redacted] Local public safety and medical resources (Table 8-1) may be activated to supplement any Orchard Storage Company LLC (Orchard Storage) response to an emergency or adverse event, if required to minimize the event's impact.

[redacted]

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## 8.3 Degree of Risk for Emergency Events

Response actions will depend on the degree of the severity of the event triggering an emergency response. Incident response will be managed via the Incident Command System (ICS) to organize, scale, and coordinate the response with third parties and communicate via a common emergency response language. Response teams will be assembled, organized, and scaled as necessary, depending on the severity of the event. At a minimum, response teams will be comprised of Orchard operations specialists and the Orchard Storage team. The teams will be expanded as needed to include specialty environmental-response resources, specialty well-intervention specialists, local first responders, and Gaines County officials. All responses will be coordinated and communicated as necessary with the relevant regulatory bodies.

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## 8.5 Infrastructure/Resource-Specific Events and Response Plans

This section outlines general response procedures to be followed during possible emergency events. The events included in this section may not necessarily present potential impacts to the USDW, but *are* events that require adequate response to assure safe and responsible operations. The responses are not intended to be exhaustive and will vary depending on the incident's specific requirements. Each situation will be evaluated based on the specific event, using best operating and engineering practices to prioritize life, safety, incident stabilization, containment, and repair or remediation. When an event has been detected, the response actions will address emergency and remedial measures related to the movement of the injectate or formation fluids that may cause an endangerment to the USDW and other events that threaten health, safety, or the environment.

If, at any time during Orchard Project operations, an employee or facility operator encounters a situation where the injected $CO_2$ stream may endanger the USDW, the following actions will be carried out:

1. Alert the Orchard Storage Superintendent.
2. Immediately cease injection.
3. Take all steps reasonably necessary to identify and characterize any release.
4. Notify the UIC Director within 24 hours.
5. Implement the Emergency and Remedial Response Plan approved by the Director.

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## 8.6 Training

Orchard Storage staff will attend, at a minimum, annual training associated with Health, Safety, and Environment (HSE). This training will include all the required Occupational Safety and Health Administration (OSHA) training (Hazardous Waste Operations and Emergency Response (HAZWOPER), etc). The staff will be trained in the ICS to ensure efficient response to incidents. In addition, the Orchard Storage staff will be provided technical training regarding the specific properties associated with $CO_2$ and standard operating procedures related to $CO_2$ storage.

Training will be reinforced by emergency drills that create scenarios to highlight specific incident responses. These drills will be as realistic as possible and may include local-county first responders. All training and emergency drills will be documented for verification.

Orchard Storage intends to implement an active outreach program with county first responders and the resident neighbors in the project storage area. Before starting $CO_2$ injection operations, Orchard Storage will provide a copy of this Emergency and Remedial Response Plan to local first responders and discuss potential response scenarios.

Per 16 TAC **§5.206 (h)(2)(C)**, Orchard Storage will provide training schedules, dates, and course outlines to the Commission annually and upon request.

## 8.7 Communications Plan and Emergency Notification Procedures

Orchard Storage intends to, as noted earlier, implement the ICS to respond to emergencies. The system, widely utilized by emergency response professionals, provides a common language and hierarchy to emergency response—a unified command—so that multiple agencies can effectively work together. The system can also be scaled to fit the incident.

A high-level structure for the ICS is as follows:


The chain-of-command members will be developed after the operating company has been formed and commercial agreements arranged.  This section will then be updated to reflect the nomination of said members.  As these positions are filled, relevant phone numbers including one for the local Orchard Storage office will be provided.

Emergency response contacts are provided in Table 8-4.

[redacted]

As appropriate, Orchard Storage will communicate with the public regarding events that require an emergency response, including the impact of the event on drinking water or the severity of the event, actions taken or planned, etc.

Prior to commencing operations, Orchard Storage will develop Emergency Operating Procedures that will include the following:

- Procedures for requesting assistance and for follow-up action, to remove the public from an area of exposure
- Provisions for advance briefing of the public within the AOR on subjects such as the hazards and characteristics of $CO_2$
- The manner in which the public will be notified of an emergency and, in case of one, the steps to be taken
- Proposed actions—*if necessary*—designed to minimize and respond to risks associated with potential seismic events, including seismic monitoring

## 8.8 <u>Emergency and Remedial Response Plan Review and Updates</u>

This Emergency and Remedial Response Plan will be reviewed annually to ensure its applicability. Additionally, the plan will be reviewed after any AOR reevaluation and following any significant changes to the project that would necessitate such a review.

Any amendments to this plan must be approved by the Director and incorporated into the permit. This plan will also be reviewed and submitted to the Director within one year of an AOR evaluation—following any significant changes to the facility (e.g., addition of injection or monitoring wells), change in personnel, or when the Director requires it.

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# SECTION 9 – FINANCIAL ASSURANCE

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**Tables**

[redacted]

## 9.1 Financial Responsibility

To meet the requirements of 16 Texas Administrative Code (TAC) **§5.205** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.82(a)(14)** and **§146.85(a)**], this section was prepared to summarize actions that Orchard Storage Company LLC (Orchard Storage) will take to demonstrate financial responsibility for injection well plugging, post-injection site care (PISC) and site closure, and emergency and remedial response. This section also provides cost estimates to conduct these activities on a project basis. While this section is submitted for each individual well, the costs included account for the seven-injection-wells project plus monitoring wells, within the pressure front area of review (AOR).

Orchard Storage will annually provide to the Underground Injection Control (UIC) Director evidence of financial responsibility as required by 16 TAC **§5.205** [40 CFR **§146.85**]. This ensures that Orchard Storage has enough financial resources to cover corrective action, injection well plugging, PISC and site closure, and emergency and remedial response, if financial difficulties are encountered. This annual report will be submitted until the Director has determined that the facility has reached the end of the PISC period. The following financial information will account for the entire AOR and be submitted to aid in the Director's determination of financial responsibility:

- The most recent audited annual report filed with the U.S. Securities and Exchange Commission under Section 13 or 15(d), Securities Exchange Act of 1934 (15 U.S.C. Section 78m or 78o(d))
- The most recent quarterly report filed with the U.S. Securities and Exchange Commission under Section 13 or 15(d), Securities Exchange Act of 1934 (15 U.S.C. Section 78m or 78o(d))
- The operator's most recently audited financial statements, if the person is not required to file a report with the U.S. Securities and Exchange Commission

## 9.2 Financial Assurance

As required by 16 TAC **§5.205** [40 CFR **§146.85**], the following financial instruments will be secured and used to provide sufficient funding for the following activities:

[redacted]

[redacted]

Table 9-1 summarizes the cost estimates for those activities—estimates that will be revised annually and account for any changes in the AOR, Emergency and Remedial Response Plan, and Injection Well Plugging Plan.

[redacted]

This instrument will remain in effect until site closure. The financial instrument will, at a minimum, contain provisions for cancelation, renewal, and continuation. If Orchard Storage faces adverse economic conditions, it will notify the Commission and file a bankruptcy notice via certified mail to the Director.

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# SECTION 10 – ENVIRONMENTAL JUSTICE ANALYSIS

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## 10.1 Introduction

The purpose of this environmental justice (EJ) evaluation is to determine if the proposed Orchard [redacted] Class VI injection well (Orchard Project)—to sequester $CO_2$ in the Permian Basin—could have a significant and adverse disproportionate environmental impact on defined communities or populations.

*Environmental justice* is defined as the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (Environmental Protection Agency (EPA) 1998). Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was published in the Federal Register (59 FR 7629) on February 11, 1994. Executive Order 12898 requires federal agencies to identify and address the potential for disproportionately high and adverse human health or environmental effects, resulting from the implementation of their programs, policies, and activities on minority and low-income populations.

The assessment of potential EJ impacts is guided by the Council on Environmental Quality's (CEQ) *Environmental Justice Guidance Under the National Environmental Policy Act* [NEPA] (CEQ 1997) and the *U.S. Environmental Protection Agency's Promising Practices for EJ Methodologies in NEPA Reviews* (EPA, 2016). Determination of EJ impacts requires three steps: (1) determining the geographic distribution of minority and low-income populations in the affected area; (2) assessing whether the action under consideration would produce impacts that are high and adverse; and (3), if impacts *are* high and adverse, determining whether these impacts would disproportionately affect minority and low-income populations. This analysis is based on the EPA definition, which considers an EJ area or community to be a location with a "meaningfully greater" percentage of minority population than the general population, or locations in which minority populations comprise more than 50% of the affected area's population.

Consistent with *Promising Practices*, EJ areas have been identified according to the following criteria, based on block group-level data from the U.S. Census Bureau's American Community Survey (ACS)[1]:

- For minority populations, use the **50%** and **meaningfully greater analysis methods**. This means, if the minority-population percentage of the block groups in the affected area exceeds 50% *OR* the minority population in the block group affected is 20% higher than the minority-population percentage in the county or state, then an EJ community is present.

[1]ACS is an ongoing survey program that provides updated demographic, social, housing, and economic data. ACS surveys 3.5 million households annually, covering more than 40 topics.

- For low-income populations, use the **low-income threshold criteria** method. This means, if the low-income population in the identified block group is 20% higher than the low-income population percentage of the county or state, then an EJ community is present.

For this evaluation, populations were reviewed relative to both the federal poverty level and the EPA's own "low-income" measure of twice the federal poverty level—using their "EJScreen" tool (described in *Section 10.3.1*).

As a Class VI injection well, Orchard [redacted] will not generate air emissions or have other significant environmental impacts during operation or construction. Therefore, Orchard Storage Company LLC (Orchard Storage) has defined the "Impact Study Area" for EJ considerations to consist of a 1-mile radius around the project site.

## 10.2 <u>Existing Conditions</u>

### 10.2.1 Demographics in the Vicinity of the Site

The Orchard Project and its 1-mile buffer are wholly located [redacted]

[redacted]

[redacted]

Orchard Storage reviewed the most current ACS data from the U.S. Census Bureau, from 2016 to 2020 (2020 vintage), to determine the presence of minority and/or low-income communities (i.e., areas with EJ concerns). [redacted]

[redacted]

[redacted]

As shown above, 58.6% of the statewide population identify as minority individuals, with 33.2% of the households considered low income. [redacted]

[redacted] in which the project site is located—is not considered a likely EJ area.

### 10.2.2 Limited English Proficiency in Vicinity of the Site

Table 10-2 presents the limited English-speaking households in the census block groups crossed by the Orchard Project. "Limited English-speaking" denotes households in which no member over the age of 13 speaks either (1) English only or (2) a non-English language—and also speaks English "very well." In other words, all members over the age of 13 have at least some difficulty with English. In total, [redacted]

[redacted]

### 10.2.3 Demographics of Region

Economic impacts of the Orchard Project are anticipated to extend throughout the areas within roughly a one-hour drive of the project. [redacted]

[redacted]

## 10.3 EJScreen Analysis

### 10.3.1 EJ Index

The EPA developed an EJ mapping and screening tool called EJScreen, based on nationally consistent data and an approach that combines environmental and demographic indicators in maps and reports. To evaluate a facility, EJScreen approximates site boundaries and, with the appropriate buffer applied, generates what the EPA terms a "Standard Report," which includes socioeconomic and environmental data on the facility site and its buffer.

EJScreen's EJ Index is a series of environmental and demographic data sets that are used to populate 12 EJScreen indicators (indices). An EJ Index combines demographic information with a single environmental indicator—such as proximity to traffic—to help identify communities that may have a high combination of environmental burdens and vulnerable populations. The EJ Index is higher in block groups with large numbers of mainly minority and/or low-income residents with a higher environmental indicator value. For each environmental factor, the EJ Index equals the environmental-indicator percentile multiplied by the demographic index for the host block group. The EPA has identified the 80th percentile filter as an initial starting point for screening an EJ Index.

The EJScreen evaluation of the Orchard Project, using a 1-mile buffer, [redacted]

[redacted]

[redacted]

As Table 10-4 shows for the Impact Study Area, none of the EJ Index measures, which identify communities with a high combination of environmental burdens and vulnerable populations, are at or above the EPA's screening threshold of the 80$^{th}$ percentile for the state and/or the nation. Based on EJScreen results for the project area, a combination of high environmental burdens and vulnerable populations appears to be absent from the Impact Study Area—and thus would not be considered an EJ area of concern to the EPA.

### 10.3.2 Sensitive Receptors

Sensitive receptors are areas and facilities where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides, and other pollutants. Sensitive receptors include, but are not limited to, hospitals, schools, daycare facilities, parks and playgrounds, elderly housing, and convalescent facilities. The review of the area found no sensitive receptors within 1 mile of the Orchard Project.

## 10.4 Project Impacts and Mitigation

Neither the Orchard Project's construction nor its operation and maintenance will result in significant and adverse disproportionate effects on EJ populations, from impacts to traffic noise, visual resources, or transportation. Resource-specific best-management practices for these resources will be employed, including screening measures for visual resources and the local school districts for transportation-related effects. The Orchard Project will *not* result in any significant and adverse disproportionate environmental impacts on any EJ communities, because there are no EJ communities within the study area. Therefore, no measures for impact avoidance, mitigation, or offset are required.

To mitigate *potential* impacts, on-site personnel will ensure (1) no leakage from below-ground storage, (2) persistent water-quality monitoring of nearby water sources, (3) regular soil-gas sampling, and (4) ambient-air-quality monitoring for $CO_2$ leakage at the well site. The Orchard Project's plans anticipate one month of construction with daily well visits and periodic maintenance to ensure quality.

## 10.5 Summary of Environmental Justice Analysis

A review of the demographics of the block group in which the Impact Study Area is located found that the area does *not* meet the established criteria of an EJ area, based on both minority and low-income populations. Further, EJScreen did not identify any EJ Index measures at or above the $80^{th}$ percentile for the Orchard Project vicinity. No significant environmental or human health impacts are anticipated in relation to the project. Therefore, no adverse disproportionate effects on populations in EJ areas will arise from the construction and operation and maintenance of the project.

## 10.6 References


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U.S. Environmental Protection Agency (2022). EJScreen Tool. Retrieved November 2022, from URL https://www.epa.gov/ejscreen

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**APPENDIX A: SURVEY PLATS**

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# APPENDIX A

Submitted to EPA via Alternative Means

# APPENDIX B: AOR

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# APPENDIX B

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## APPENDIX C: CONSTRUCTION

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# APPENDIX C

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# APPENDIX D: METALLURGY

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# APPENDIX E: TESTING AND MONITORING

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# APPENDIX E

Submitted to EPA via Alternative Means

# APPENDIX F: EMERGENCY OPERATIONS

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# APPENDIX F

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# APPENDIX G: PLUGGING AND ABANDONMENT

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# APPENDIX G

Submitted to EPA via Alternative Means

# APPENDIX H: FINANCIAL ASSURANCE

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# APPENDIX I: REFERENCES

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